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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CII.—No. 2659.] *LONDON: FRIDAY, DECEMBER 15, 1916.* [*Registered at the General Post Office as a Newspaper.*] [PRICE.. 6d. BY INLAND POST..6d.

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H.M. Office of Works, &c.,
29th November, 1916. F 637

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H.M. Office of Works, &c.,
11th December, 1916. F 714

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THE ARRANGEMENT OF MACHINE SHOPS.—No. VIII.

By JOSEPH HORNER.

THE illustrations of workshops which accompany the present article show examples of the latest and most advanced practice of tool and gear making, in which laboratory work and microscopic examinations go hand in hand with the heat treatments of the hardening department. The firm of E. G. Wrigley and Co., Limited, was commenced by Mr. E. G. Wrigley in premises off Aston-road, Soho, Birmingham, in July, 1897. The original business comprised the manufacture of small tools, twist drills, milling cutters, &c., in addition to which the firm did gear cutting for the trade. When the business was getting into swing the automobile was becoming popular, and one result of this was the large amount of attention that was devoted to the small high-speed gears for motor vehicles.

Within five years a migration from the original site became necessary, and in 1902 the works were removed to the present position in Foundry-lane. Mr. J. D. Steven was installed as manager in 1906, becoming shortly after managing director. Under his supervision the works have developed rapidly along very definite lines. The gear-cutting department has grown into one of much importance, and the small tool factory has been very greatly extended.

The plan, Fig. 56, on the present page, shows two factories, the older one abutting on Foundry-lane, the later one—completed last March—facing Anne-road. The plan shows how space is hampered by adjacent workshops. For this reason the new works are built with three floors, with a basement used as a test house, while the older works has a ground floor arrangement. A second wing to the new factory is now in course of erection, occupying a portion of the area seen at the right hand of Fig. 56. Quite recently it has been decided to build the whole of the Anne-road frontage and another wing, which will approximately double the new works. The whole of the extension is due to the automobile business of the firm, as they have sufficient space to cope with the small tool productions. The new building will be put up on the same lines as that already erected. The bottom floor will be used as a fitting shop, and the two top floors as machine shops.

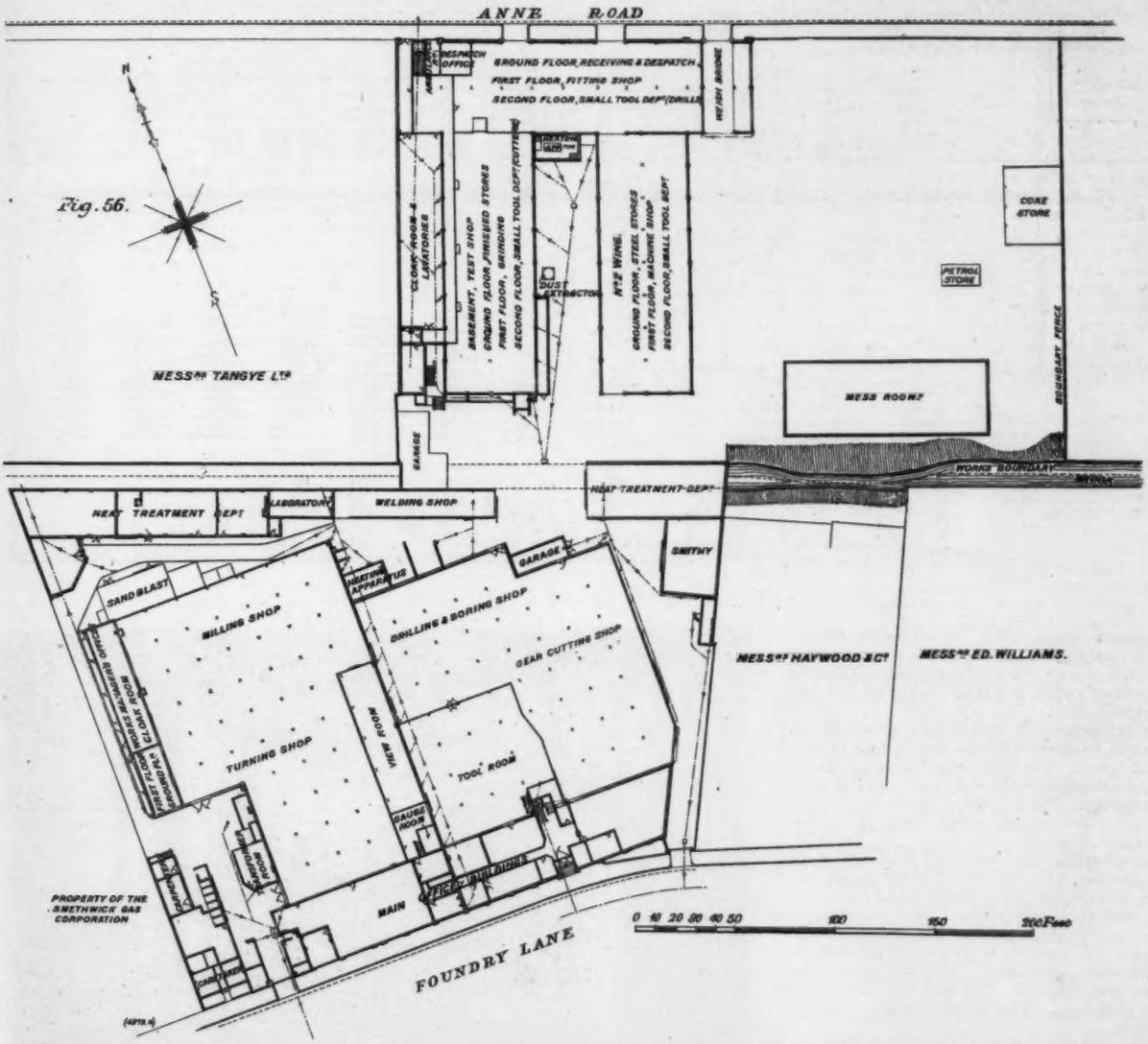


Fig. 56.

The ground floor of the No. 2 wing is laid out as steel stores, as shown in Figs. 57 and 58 on page 576. We shall refer to this department later on.

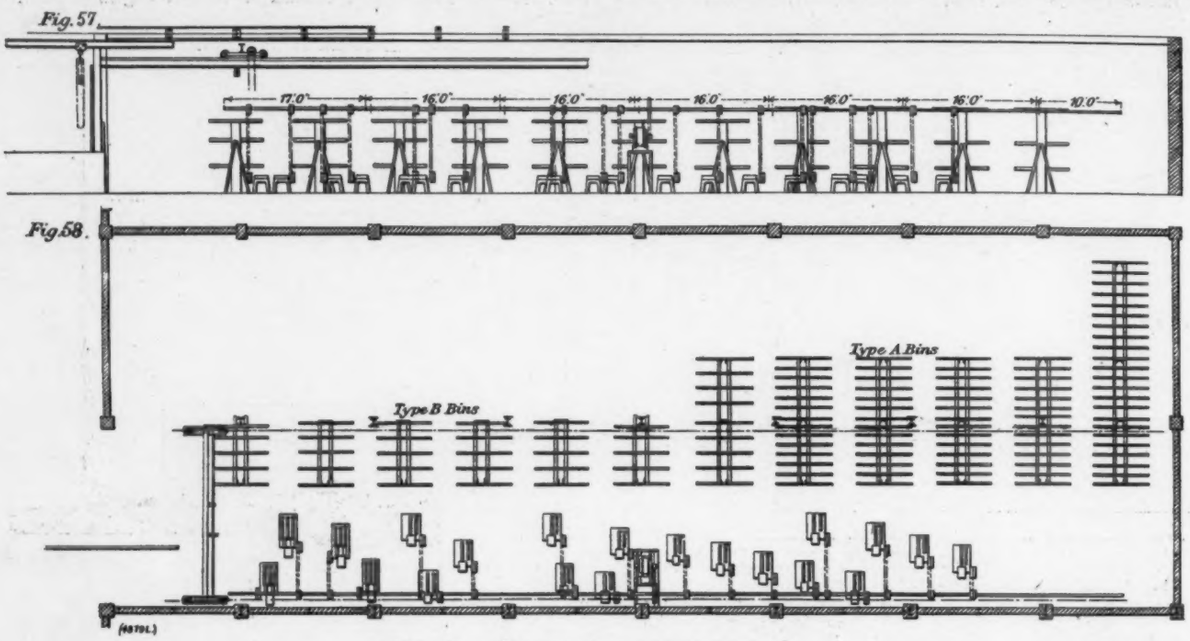
The basement of the Anne-road factory is arranged as a test-house. It is provided with a large test bed made of H-section girders, set in concrete. Suitable switch-boxes are provided for motors, and a pipe line is laid down to convey water, supplemented by a proper drainage system. This building is served by two lifts, an Easton lift which serves the three main floors, and a Medway push-button control lift. This is found necessary owing to the difference in level between the old and the new works. By means of the lifts and a number of Cowan trucks a very efficient transport service is arranged. The despatch bay is fitted with a power-driven hoist by Herbert Morris and Co., Limited.

The floors throughout the works and offices are of maple, laid on an underfloor of deal, which is set in bitumen on concrete. This makes a firm and hard floor which renders transport easy. The lighting is done with half-watt electric lamps, which give a good diffused light. Originally the machines and benches were provided with individual lights. The lighting circuit takes alternating current at 110 volts.

Electric driving is universally employed. It was installed in 1912, prior to which power had been supplied by three gas engines. The current is three-phase alternating, 440 volts for the power circuit. Electric motors are standardised at 20

and 25 h.p. They are interchangeable, so that in the event of a breakdown a spare can be rapidly installed. The majority of the machines are belted, but a number have individual motors. All the line shafting in the Anne-road shop is of a standard size, and runs in Hoffmann ball bearings.

Provision is made for ventilation and heating. Part of the Foundry-lane works is ventilated by a modification of the plenum system, the other part being ventilated by means of draught induced by fans, and heated by means of hot water circulation. In the Anne-road building the heating is by



FIGS. 57 AND 58. LAY-OUT OF STEEL STORES.

low-pressure steam. The ventilation is natural and extremely good. It should be borne in mind that the bays are 12 ft. 6 in. in height from floor to floor, and only 45 ft. in width. In the ground floor the height is 20 ft.

The arrangements of some of the principal departments can be studied in the photographs in subsequent figures. The latest scientific researches are being translated into the everyday practical work of the factory. The location of these departments is, as we have already stated, denoted on the general plan, Fig. 56.

A metallurgical department is in charge of an expert chemist, who has control of the heat treatment. The preparation of specimens for the microscope and their examination and photography occupy another department. The heat-treatment shop, Fig. 59, annexed, is provided with furnaces by Brayshaw, Richmond, Wright, Brown and Sharpe, and Gibbons. The sand-blast apparatus is by Tilghmans. The Brinell hardness test is employed.

The ground floor buildings abutting on Foundry-lane are covered by seven saw-tooth roofs supported on rolled joists. They include the turning, milling, drilling and boring, and gear-cutting shops, the tool room, and the view room.

The turnery, Fig. 60, page 588, comprises long vistas of lathes by the leading firms, Messrs. Herbert, Ward, Jones and Lamson, Dean Smith and Grace, Tangye, Pratt and Whitney, and the American Tool Works. There are eight Potter and Johnston automatics, two La Pointe tension drifting machines, and Archdale thread-milling machines. These are all driven by belting. Two 36-in. Bullard vertical lathes are fitted with their own motors.

The milling department is equipped with machines by Messrs. Brown and Sharpe, the Cincinnati Company, A. Herbert, Becker, and the Rockford Company. In the drilling and boring shop are machines by Asquith, Muir, the Cincinnati Company, Bickford Company, A. Herbert, and multiple drills by Pratt and Whitney, and Fox. The boring machines are by Messrs. Churchill, the Universal Tool Company, A. Herbert, Rochester, and Dickenson.

The gear-cutting department, Fig. 61, page 588, is provided with a battery of Brown and Sharpe machines of various sizes, a number of the Wall-work worm-gear cutting machines, 15 Bilgram gear planers by Reinecker, three Gleason bevel-gear planing machines, and seven Fellows gear shapers, shortly to be augmented. Also with some thread-drill grinding machine, and a Lumsden No. 1 oscillating tool grinder. There is a planing machine by Messrs. Ward, and a shaping machine by Flather. Drilling machines by Rice, and Ward, are also included among other machines of the types usually found in tool rooms. In the gauge room adjacent there is a Pratt and Whitney measuring machine. The instruments for measuring thread gauges are made on the premises to the company's own designs.

In the small tool department view room, Fig. 62, page 588, enclosed by expanded metal, the work is

FIG. 59. THE HEAT-TREATMENT SHOP; MESSRS. E. G. WRIGLEY AND CO., BIRMINGHAM.

milling machines by Pratt and Whitney, various makes of tooth-rounding machines, and a Parkinson self-recording bevel-gear testing machine.

The tool room is a large department, and of first-class importance in a works of this character. It is an extensive machine shop in itself. Here are lathes by Pratt and Whitney, the American Tool Works Company, the Hendey Company, and the Bradford Company. The Gisholt Company and Brown and Sharpe grinding machines are in evidence, a Brown and Sharpe surface grinder, a Heald twist-

done mostly by girls, who are provided with seats and are adept in the use of the gauges. Automobile parts are viewed by men, being less of a standard nature. A Brown and Sharpe spur-gear testing machine forms a part of the equipment.

The smithy is not a large department, because the majority of the tools are manufactured from rods. Stampings and forgings are bought in quantities from specialists. The work done there consists chiefly of millwright's requirements for the shops, tool-making, experimental work and odd jobs.

A 3-cwt. pneumatic hammer by Messrs. B. and A. Massey is provided, driven by its own motor.

The departments comprised in the newer portion of the works are marked on the plan, Fig. 56, page 575. Here the fitting shop, of which a view is given in Fig. 63, page 588, is divided into bays, each having its own axle or gear-box speciality for assembly. Messrs. Wrigley make large numbers of these boxes, fitted complete for commercial and other vehicles, all self-contained and ready to be put into place. As will be seen by the photograph, Fig. 63, the benches are ranged across the shop, with a wide gangway down the centre. Each bench has several vices and drawers, shelves below and a convenient backing above. The walls are occupied wholly by windows, except for the necessary masonry columns that go up to the roof and partly support the floor joists, which are carried at the centre by built-up columns of H-section. A hand crane and Cowan trucks serve for transport. A Tangye wheel press is used for forcing axle sleeves into castings and for similar purposes.

The small tool department includes that for the manufacture of cutters and that for twist drills. The total area is 13,150 sq. ft., shortly to be increased to 19,230 ft. The cutter department is provided with lathes by Messrs. Archdale, Herbert, Ward, Smith, Barker, and Wilson. The relieving and backing-off lathes are of the Reinecker types. The grinding machines are by Guest, Reinecker, Archdale, Brown and Sharpe, and others. The milling machines are by Brown and Sharpe, Parkinson, and the Cincinnati Company. In the twist drill department, lathes by Ward, Archdale, Hunt, and Reinecker figure largely. The grooving machines are of Messrs. E. G. Wrigley's own design, and some also by Reinecker. A large group of Lincoln milling machines is to be seen. The grinding machines are by Brown and Sharpe, Churchill, Guest, and others. There are view rooms to each side of the works.

The amount of tool steel used in these works is enormous. The ground floor of the No. 2 wing, now approaching completion, is laid out as a steel stores, seen in elevation in Fig. 57, and in plan in Fig. 58, page 576. The equipment includes bins or racks built of steel, arranged down the centre to carry the steel rods, and covered and served by a light overhead travelling crane. A row of hacksaws is ranged along one side, driven from shafting along the wall actuated from a motor at the centre of the length. The saws hit and miss (see Fig. 58) in order to avoid interferences of the rods being cut. They include machines by Messrs. Charles Wicksteed and the Fortuna Company. There is also a Butler rotary cutting-off machine and a Davis machine.

Messrs. Wrigley are justly proud of these works, which have been and are still in course of development on the most advanced lines. The works force at present consists of 618 employees, of which 142 are women. The office staff includes 63 men and 49 women. This is a large proportion to the works force, and is a result of the high specialisation of the firm's products and of the rather complicated organisation. The card index and loose leaf filing system is adopted. The great secret of managing such a business lies in the systematisation, which can be rapidly extended in any direction, and which is so flexible that rapid changes can be readily accommodated.

The welfare side of the organisation is recognised. A canteen is provided for the works employees, which will accommodate 300 men and 150 women. Bubble fountains are provided on every floor for drinking purposes. The lavatories have white glazed open earthenware troughs with rose taps, so that perfectly clean water can be used for washing purposes. A mixing valve under the control of the lavatory attendant ensures that the water is at a suitable temperature. There is also a large staff mess-room and separate kitchen.

RUBBER.

THE present time is hardly opportune for the publication of researches on rubber. Researches are going on and are presumably very active on the Continent. But results of industrial value are less likely than ever to be published, and it must be acknowledged, moreover, that the solution of the synthetic rubber problem seems once more to be restricted to its scientific interest—if we may disregard war conditions. Things looked very different ten and five years ago. It had then been established that certain synthetic products were identical with, or at least very similar to, caoutchouc; various investigators claimed to have prepared artificial rubber, and the lull that subsequently set in in the rubber boom was not unnaturally regarded in some quarters as the usual period of quiet development which intervenes between the general solution of a technical problem and its industrial application. But the activity in rubber synthesis had really suffered a severe check because the commercial incentive had gone. Up till 1910 rubber prices had been rising, reaching 12*s.* 6*d.* per lb. in that year. With cheap raw materials—and all sorts of materials were being tried—capital could be risked in developing industrial rubber processes. The increasing importance of rubber, however, and the ruthless depletion of the rubber stores of Nature had not failed to stimulate an energetic extension of rubber plantations. In 1901 the Malay States had not started to plant rubber, and only 2,500 acres were under rubber in Ceylon; by 1912 the figures were 621,000 and 230,000 acres, and the bulks of rubber exported had risen from 0 and 35 tons in 1901 to 18,956 and 6,697 tons in 1912. The world's supply of plantation rubber was estimated at 28,500 tons in 1912 and at 98,000 tons in 1915. With the increasing supply rubber prices went down steadily, to 2*s.* 4*d.* in 1915, and the prospects of synthetical rubber became more and more problematical. Yet there is need of research. For it is not only the main problem, the synthesis of rubber, which remains partly solved only; there are many other problems connected with rubber, the bearing of which cannot be foreseen. That the subject may be discussed at present is shown by the fact that two papers were recently read before the Edinburgh Section of the Society of Chemical Industry, one by Mr. B. D. W. Luff, F.I.C., on "Rubber Synthesis," and one by Mr. B. D. Porritt, F.I.C., on "Raw Materials used by the Rubber Manufacturer" (see Journal of the Society of October, 1916).

Rubber has interested eminent chemists for little short of 100 years. A. Bouchardat, Dalton and Liebig were among the early investigators. Greville Williams, distilling rubber as Barnard had done in 1833, isolated in 1860 from the crude distillate a liquid which he called isoprene and which slowly turned sticky, and other hydrocarbons. G. Bouchardat converted the liquid isoprene, by treatment with hydrochloric acid, into a solid which did not contain chlorine and resembled caoutchouc. Tilden, in 1882, showed that this conversion was of the nature of a polymerisation (the union of a number of relatively simple molecules of a body to a compound molecule), and that isoprene could also be obtained, in very small quantities at any rate, by passing turpentine vapours through hot tubes, a kind of cracking process. Euler then, in 1897, succeeded in preparing isoprene synthetically, and his researches and those of Ipatiew settled the constitution of isoprene, which is regarded as β-methyl divinyl, an unsaturated hydrocarbon of the formula $C_5H_8 = CH_2 : C(CH_3) . CH : CH_2$, as proposed by Tilden.

Since then research has been proceeding in two, or rather four, main directions. First to find out how many molecules of isoprene are polymerised in the essential constituents of caoutchouc, assuming this constituent to be $(C_5H_8)_x$, in other words, to determine the unknown x; and further to ascertain the character and importance of the other regular constituents of rubber, which are considered as less important than caoutchouc, though not as unessential. The second line of research concerns the raw materials suitable for the preparation of artificial rubber, and, as already pointed out, the fall in the prices of rubber has rendered that problem more and more difficult. The third problem is the vulcanisation of rubber. Technically that problem has long since found a solution, or several solutions; but scientifically vulcanisation is still little understood, and as long as that remains so, there is little hope of success being realised in the recovery and regeneration of waste rubber, the fourth big problem.

The polymerisation of isoprene, especially the spontaneous auto-polymerisation to something like caoutchouc, is a slow process. Wallach (1887) hastened this auto-polymerisation by exposure to light; Pickles, 1912, observed that isoprene kept in a bottle (mostly in the dark) for 3½ years turned into a syrup which coagulated on the addition of alcohol. Harries, 1910, treated isoprene with glacial acetic acid in sealed bottles to hasten the polymerisation, and was still more successful when treating isoprene with metallic sodium in the cold. The amount of artificial rubber so far prepared being probably very small—nothing is known as to the success of the processes of the Elberfeld and Ludwigshafen dye firms—and all artificial rubber being of recent origin, the practical question—how long will the so-called artificial rubber behave like natural rubber, vulcanised or not?, can hardly be answered, and chemists have to rely on the chemical reactions of natural and artificial rubber. Harries, who has specially studied the reactions, suggests that two chemical molecules of C_5H_8 are united to a physical molecule, the latter being itself polymerised to an unknown extent in the caoutchouc. Pickles thinks that C_5H_8 molecules unite to a long chain or ring, and that the number of molecules is indefinite and not the same for different kinds of rubber. There are other suggestions, and Caspari finds that wild rubber and plantation rubber differ and contain two varieties of caoutchouc; considering the great differences between the same wild and cultivated plants, flowers, fruit, &c., that is not at all improbable and further complicates the problem. It is indeed doubtful whether caoutchouc is really one homogeneous substance; its colloidal nature renders investigation very difficult.

The study of different raw materials indicates, moreover, that rubber-like substances are not all of the isoprene type. Some of the most satisfactory artificial rubbers seem to be of the butadiene type C_4H_6. This substance is also known as erythrene or divinyl, and being characterised by a double bond like isoprene it readily polymerises too; but it can hardly be expected to polymerise to a compound $(C_4H_6)_x$. Many materials have been tried in the manufacture of artificial rubber, as we have stated already. Rubber itself and turpentine are too expensive for anything but scientific research; yet turpentine products figure in artificial rubber recent patents, partly in connection with waste rubber (G. Reynaud). Sabatier used cresols, which can hardly be spared at present. W. H. Perkin, junr. (1912), fermented starch in such a manner as to yield mainly butyl alcohol, which he converted into butadiene. When the fermentation of starch is so conducted as to give ethyl (common) alcohol, and part of this alcohol is oxidised to aldehyde, the mixture of vapours can be converted into butadiene by withdrawing the elements of water. This can be effected in many ways, and Ostromyslenski described in 1915 as many as 29 methods for obtaining erythrene or isoprene from alcohols, aldehydes and other organic compounds. The cracking process of A. Heinemann,* which was demonstrated in London at the Rubber Exhibition of 1911, also started from alcohol obtained from carbohydrates like starch, cellulose, sawdust, &c. Other processes aim first at the production of laevulinic acid, which is intimately related to caoutchouc. All sorts of resins, oils, the latex of many plants, fish, &c., have been suggested as raw materials, both for making rubber and rubber substitutes.

So far we have not mentioned the constituents of rubber which are not hydrocarbons. There are, in addition to about 94.5 per cent. of caoutchouc in washed and dried rubber, about 2.5 per cent. of resins and 2.5 per cent. of insoluble nitrogenous proteids and other organic compounds, besides 0.25 per cent. each of ash and of moisture. It is not justifiable to speak of these constituents as impurities; they strongly affect the behaviour of the rubber exposed to the influences of oxygen and light, of time and mechanical stress, and when treated with other substances. The removal of these additional constituents would be both very difficult and undesirable. The resins to a certain extent prevent the oxidation—ozonisation it was called by the early

* See ENGINEERING, vol. xcii, page 75

investigators—to which rubber is liable; they also play a part in vulcanisation. That the proteids do so likewise has recently been established again in the agricultural department of the Malay States by Eaton and Grantham, who find that plantation rubber and wild rubber differ in their percentages of proteids, that plantation rubbers fluctuate in this respect more than wild rubbers, and that for this or other reasons the vulcanisation of plantation rubbers cannot so easily be conducted on standard lines. Whether the inferior strength under mechanical stress sometimes ascribed to plantation rubber is merely a consequence of the more difficult and less efficient vulcanisation remains to be seen. Inefficient vulcanisation is certainly responsible for much trouble with rubber goods.

Rubber has been vulcanised since Goodyear mixed it with sulphur in 1839. Pure rubber is hardly used at all; it is affected by light, though Harries could not trace any chemical change due to light. Soft rubber contains about 5 per cent. of sulphur, hard rubber or vulcanite about 35 per cent. of sulphur. When a mixture of the former percentage is heated by steam at a pressure of about 50 lb. per square inch for two or three hours, soft rubber results; when the heating of the latter mixture is continued for a longer period at higher pressure, hard rubber is obtained. The hard rubber may be regarded as (C_5H_8S), one molecule of sulphur having been taken up per molecule of isoprene. The nature of the compound resulting when 5 per cent. of sulphur and less—1.5 per cent. seems to be sufficient—is used is unknown. The sulphur certainly enters into combination with the rubber, and the resulting compound may be disseminated through the mass as in a solid solution. These assumptions do not explain at all, however, why the proteids and resins play a part in vulcanisation. That one has to deal with compounds is shown by the fact that the sulphur which has once been taken up by the rubber cannot be extracted from it again. In reclaiming waste rubber, the substance used as fillers may be more or less removed, but the reclaimed rubber is insoluble in the solvents for pure rubber and retains the sulphur and a portion of the fillers; and there is, therefore, no real regeneration.

Vulcanising (or curing) must be distinguished from compounding (charging with fillers), although the two processes, again, influence one another. Vulcanisation may be hot or cold. In the "steam heat" process recommended for textiles with a thin rubber coating, *e.g.*, steam is applied under pressure, condensation of steam on the material being prevented; the objection to the process is that any uncombined sulphur in the material may "bloom up" to the surface and spoil the colour. The "dry heat" process yields only black articles, because the litharge always added in this case forms black lead sulphide; the process is carried out in steam-coil heated air chambers, in which part of the sulphur is volatilised.

In the "pressure" process for motor tyres, buffers, &c., the vulcanisation takes place in hot moulds under pressure. The "cold curing" relies on the vulcanising action of sulphur monochloride; there is no danger of blooming, the cold-cured goods have a velvety appearance, but the brilliant colours do not always retain their brightness. The goods may be dipped in a solution of sulphur chloride in carbon disulphide, or may be exposed to the vapours of the chloride. In both the hot and the cold vulcanising sulphur is the active element, and it is very remarkable that in spite of many varied attempts no substitute for sulphur has been found. The nitrobenzene derivatives recently recommended, as accelerators rather than as vulcanisers, act, according to B. D. Porritt and W. G. Martin, as oxidisers, likely to deteriorate the rubber.

Rubber is compounded with a great variety of substances. Even unvulcanised rubber is so treated, because it is mechanically too soft, or because it is to be coloured. Mineral matters used for this purpose are zinc oxide and magnesia, further, the sulphides of antimony and of arsenic (yellow), zinc chromate, green oxide of chromium, ultramarine, lampblack, &c.; organic dyes often do not stand hot vulcanisation. The white and the brown rubber substitutes obtained by the action of sulphur chloride on rape-seed oil or on other oils should also be mentioned here. Other additions act more as accelerators; litharge, lime, magnesia and certain organic compounds belong to this class. With their aid it is possible to vulcanise in the hot at a comparatively low temperature and to correct the vulcanisation of materials which require different treatment for the outside and inside or for different parts.

We will not enter into rubber reclamation, and the still unattained rubber regeneration—it is too big a subject. There are many unsolved problems quite apart from the artificial rubber question. We are by no means anxious to replace natural rubber by some factory product. On the contrary, the natural product is preferable, provided it can be raised in plantations under humane and healthy conditions. We have had enough of rubber horrors, which, for all we know, may not be suppressed yet by any means. But rubber research must continue. For one thing, the fluctuations in plantation rubber should be cleared up, considering that rubber is grown, gathered and coagulated under much more uniform conditions than can be observed in the case of the wild trees.

TESTS OF CARBON DIOXIDE RECORDERS.

Furnace-control devices, especially of the carbon dioxide recorder type, have become an indispensable accessory of modern boiler installations. There are quite a number of CO_2 recorders of different types on the market, and their use would be more common still if the instruments were not in a sense complicated. The ordinary care of the recorder can be entrusted to the fireman. But the adjustments require experienced hands; a systematic error is not easily detected and remedied, though the actual repair needed may be slight, and when the engineer learns that changes in the boilers house temperature, draught, &c., may influence his instrument in ways beyond his control, he becomes distrustful. Little has been published on independent reliability tests of CO_2 recorders and on their peculiarities. The account of a series of laboratory and service tests of seven different types of CO_2 recorders and indicators conducted by Messrs. J. F. Barkley and S. B. Flagg, on behalf of the United States Bureau of Mines (Bulletin 91), will therefore be welcomed by engineers. The Bulletin explains that the conclusions drawn concern only the instruments examined and may not hold for later improved apparatus. But the value of the research rather lies in the general information as to the behaviour, installation and treatment of such instruments than in the comparative merits of special types.

The tests were undertaken with the approval of the respective instrument makers and with the understanding that the results would be published. The instruments tested were the following: (1) The bimeter CO_2 recorder of the Cambridge Scientific Instrument Company, England; (2) the Simmance-Abady CO_2 recorder of the Precision Instrument Company, of Detroit, Michigan; (3) the Sarco combustion recorder of the Sarco Engineering Company, of New York; (4) the telezometer of G. A. Schulze, Berlin-Charlottenburg; (5) the Uehling CO_2 machine of the Uehling Instrument Company, Passaic, New Jersey—these five instruments being automatic recorders; further, two indicating instruments: (6) the CO_2 thermoscope of the Underfeed Stoker Company, London; (7) Dr. A. Schmid's pocket CO_2 indicator, made by J. G. Cramer, of Zürich, Switzerland. The Bulletin briefly describes and discusses the instruments and directions for their use, the adjustments, and sources of error to be guarded against, outlines the tests applied, tabulates some of the results, and gives a summary of the conclusions, both general and special, for every instrument.

The tests were made partly in the laboratory and partly in a boiler house under service conditions. In the laboratory the instruments were suitably mounted close to one another. In determining the time lag, the instrument was run, in the laboratory, at a definite speed under regular working conditions, with constant draught and temperature, a gas of unvarying CO_2 content being drawn from a gasometer through the instrument. When a number of concordant determinations had been obtained, the CO_2 percentage was altered, and the time interval was noted after which the instrument began to respond to the change. That interval amounted, with the different instruments, to 8 minutes as a maximum. A considerably longer period (the time lag) elapsed until the instrument recorded the correct new value. In these experiments the gas was either passed through the ordinary filter of the instrument or was directly admitted into the instrument proper. The general accuracy of the various instruments varied between 0.1 and 0.5 per cent. of CO_2; to evaluate the significance of that statement it should be noted that the chemical analyses by which the records were checked might themselves have been wrong by 0.2 per cent. Generally speaking, therefore, all the instruments were fairly accurate. But they differed under varying conditions. In order to ascertain the influence of changes in the boiler-house temperature, the room temperature was suddenly lowered say, from 98 to 75 deg. F., other conditions being kept constant. The boiler draught was varied between 0 and 1½ in. of water, apparently—the full particulars are not given. The mechanisms were also examined.

The endurance tests were conducted under service conditions, and continued for several months, the care and attention required to ensure correct records being noted. Every eighth day the devices were standardised again. Attention was also paid to the frequency of the necessary renewals of reagents (caustic alkali). This is an important point. With several of the instruments it was difficult to ascertain whether there was sufficient reagent left to go on with—except by check analysis, which would require a gasholder charged with gas of a known CO_2 percentage and other apparatus; the reagent had therefore to be renewed as directed by the makers. The life of a single charge is expressed—in the Bulletin—in per cent.-hours; 1,000 per cent.-hours means, *e.g.*, that the reagent sufficed to deal with a 10 per cent. CO_2 gas for 100 hours, or with a 5 per cent. CO_2 gas for 200 hours, &c. The values found ranged from 500 to 5,000 per cent.-hours. The renewal of the reagent—which took up to 45 minutes—adjustments, repairs, &c., should, according to the Bulletin, be entrusted to somebody thoroughly familiar with the instrument, whilst the ordinary care, winding up the clock, changing the chart, inking the pen, &c., might be left to the fireman, who would have to devote from 5 to 15 minutes daily to this work. The expenses for the maintenance of the instruments during the period of the tests were practically confined to the cost of the reagents, disregarding time. The indicating instruments passed well on the whole; they were found correct within 0.3 per cent.

We will give some particulars, taking the instruments in the order above indicated. Several of the instruments have been described in our columns, but not always in the form in which they were submitted to this investigation. We repeat the main conclusions without comment; the report of the researches is too condensed to admit of critical discussion.

(1) The bimeter recorder consists of two gas meters, a water-jet pump, and a recording mechanism. The gas passes through a cooler into the first meter and into the absorption chamber (a jar charged with slaked lime); as the gas is heated by the chemical reaction, it is again sent through the temperature equaliser (another portion of the cooler) and then remeasured in the second meter, which runs about 4 per cent. slower than the first. Both the meters are filled with oil, and the pen is actuated by a differential drive between the two meters. The accuracy of the records was found to be $\pm$ 0.5 per cent. CO_2; this accuracy was not affected by changes in the room temperature, boiler draught and speed (number of records per hour). The time lag ranged from 28 to 35 minutes, indication of a change being recognisable in 5 minutes. When operating at 23 records per hour, 1.73 cub. ft. of gas were drawn through the apparatus per hour; the maximum rate was 30 analyses per hour. Repacking a lime jar took 30 or 45 minutes; the per cent.-hours were 555 to 1,194 (740 average). The degree of activity of the reagent being not easy to ascertain, the reagent should be changed as often as recommended by the makers. The fireman's attention was wanted for 5 minutes daily; the pens

gave considerable trouble, and the water pipe was liable to clog up when dirty water was used.

(2) The Simmance-Abady CO_2 recorder belongs to the type of float instruments and meters, several of which we have illustrated on various occasions. A float sinking in a siphon tank raises a bell into which the flue gas is drawn through the caustic potash solution. When the gas does not contain any CO_2, the bell rises to its full height; when CO_2 is present and is absorbed, the bell does not rise to its full height. The time lag was found to range from 25 to 34 minutes. Operating at 16 or 17 records per hour, the instrument drew 0.6 cub. ft. of gas per hour. Under proper adjustment the records were correct within ± 0.1 or 0.2 per cent. CO_2, *i.e.*, as correct as the chart could be read and as correct, also, as the experimenters' checks permitted to be determined. Changes in the room temperature, draught and speed affected the accuracy by 1 or 1.5 per cent. The greatest source of trouble was a persistent leak of gas through the joint between the caustic potash steel tank and its cover; this joint was repeatedly painted with asphaltum paint, but a leak would reappear. The change of the solution took 15 minutes, the charge lasted 5,100 per cent.-hours; the change had to be made as recommended by the makers. The ordinary daily attention required was 8 to 10 minutes. There was considerable trouble with regulating the continuous water supply so as to maintain the proper water levels, and the use of this part of the apparatus was abandoned.

(3) In the Sarco combustion recorder the power is derived from a fine stream of water at a head of about 2 ft. entering the instrument through a small glass injector, which is supplied in various sizes to adjust the speed of the machine. The instrument consists of a system of siphon tubes and reservoirs. The stream-water compresses the air above the water in a power vessel. The filter is inserted in the main pipe as close to the boiler as possible. Owing to this arrangement the time lag due to the instrument proper and to the gas line and filter (9 minutes for indication within 0.5 per cent. and 12 minutes for a complete change in the record) cannot be compared with those of the other instruments in which filter and gas line are included. Thirty analyses per hour are recommended by the firm; 50 analyses could be made. Properly adjusted, the accuracy was ± 0.4 per cent.; this accuracy was not affected by the boiler draught, but was affected to 0.5 or 1 per cent. by changes in room temperature and in rate of speed. The renewal of the caustic potash solution required 5 minutes; the per cent.-hours were 2,260 to 2,490 (2,375 average); the time of exhaustion could fairly well be estimated. The fireman's attention was wanted for 8 to 10 minutes daily. The rubber connections lasted 12 months, those under the potash tank only 2 months; these parts were readily replaced. The nib type of pen gave considerable trouble.

(4) In the telezometer CO_2 recorder two centrifugal fans, driven by a constant-speed electric motor, draw in, the one air, the other flue gas, setting up a difference of pressure, depending upon the densities of the media, in the inlets and outlets of the apparatus, and a lever records the resultant of the four static pressures. The records are continuous. The experimenters state that they do not offer any instructions regarding the erection and operation of this machine owing to the difficulty of maintaining the necessary operating conditions. When a change was made by admitting a gas of higher CO_2 content, the time lag was only 6 or 8 minutes; when the new gas was of lower CO_2 content, the time lag was 5 minutes for records within 0.5 per cent., but 30 or 34 minutes for a complete record, but evidence of a change in the composition was almost at once recognisable. Normally, the telezometer drew 2.4 cub. ft. of gas per hour, and the accuracy was 0.2 per cent.; changes in room temperature, boiler draught, and particularly in fan speed (changing the motor speed from 1,600 to 2,000 r.p.m.) affected the accuracy (by 3.3 per cent.). Very little is said in the Bulletin about this instrument on the whole; no reagent being used, no attention is wanted in this respect.

(5) The Uehling CO_2 machine. Broadly, the instrument may be described as an open pipe-line in which pressures (below atmosphere) are measured at different points. Suction at the far end draws gas through the filter past a mercury gauge through a valve to a second measuring gauge and a point at which a second suction acts so that the gas current divides in proportion to the relative suctions. In its further path the gas flows through another valve, a cotton filter, a steam pot (in which the gas is heated up in its coil), and is forced through a high resistance (a small orifice) into the caustic solution, and past three more gauges, indicating respectively the pressures at the front of the instrument, in the boiler room and on the chart, all these pressures being differential. The gas flows on through another cotton filter, returns to the steam pot, to be heated up again, is sent through a second orifice, and escapes. There are so many parts and taps that only full illustrations could explain the construction. The time lag was 5 or 8 minutes for indications within 0.5 per cent., except when gas free of CO_2 was admitted to the sampling tube; the lag then was 70 minutes, the last drop being exceedingly slow. Evidence of a change of composition was recognisable almost at once. Run under normal constant conditions the accuracy of the continuous records was within 0.1 per cent.; this was not affected by a change in the boiler draught, but slightly affected by the temperature. The caustic soda is supplied in pasteboard cartons, which lasted from 500 to 1,185 (average, 870) per cent.-hours. The carton is inserted in a metal case, which becomes hot in that portion in which the reaction is going on. The reaction proceeds upward, and by placing the hand against the case the approaching exhaustion could thus be estimated. The machine claims about 8 or 10 minutes of the fireman's daily attention.

(6) The CO_2 thermoscope is an indicating apparatus for occasional use. It consists of a cylinder fitted with a plunger for drawing in the flue gas, a small receptacle for the brass cartridge, which is charged with granular caustic soda, and a thermometer whose mercury bulb is so blown out into an inverted cup that the cartridge fits into the hollow of the bulb, which surrounds it like a jacket. By operating a three-way cock at the bottom of the cylinder and working the plunger, the instrument is made to act as a pump; the cartridge is pierced just before insertion and further pricked by the plunger. The rise of the thermometer indicates the CO_2 percentage. A maximum of 6 analyses could be made per hour with an accuracy of 0.3 per cent. When the thermometer is artificially cooled after an analysis, more records may be obtained; otherwise the lag of the mercury may lead to errors of several per cent. Each analysis requires a new cartridge; the instrument is compact, portable and convenient.

(7) Dr. A. Schmid's pocket indicator is a glass tube provided with two bulbs and two taps. The lower tap is taken out to fill the lower bulb with caustic potash solution. When the instrument is not in use this glass tap is replaced by a rubber stopper. The gas is introduced through the nipple of the tube above the upper tap by the aid of a rubber pump; during operation the tube is first held inclined, so that the liquid enters the upper bulb, and then downward and immersed in a beaker filled with water. From 17 to 20 analyses, correct within 0.2 per cent., could be made within an hour. One charge of caustic sufficed for several hundred analyses. After that the apparatus should be purged by means of the pump. The trouble most likely to be experienced was the sticking of the glass cock owing to the action of the caustic. The device is compact and portable.

Some hints on the installation of gas lines ($\frac{3}{4}$ in.) for CO_2 recorders close the report of this investigation. Comments appear inadvisable, as we have said already, because the report is very condensed and the tabular material far too meagre. But the report is certainly very useful, and may teach users of CO_2 recorders to look out for unsuspected sources of trouble as well as for their remedies. One idea presents itself. If the pocket instruments be convenient and reliable—and there is no reason to doubt that, for simple apparatus for ready CO_2 analysis are well known to chemists—these instruments might be used for the occasional checking of the automatic recorders. The experimenters seem to have worked with commendable care. But their literature references are defective. Three references are given to our own columns, one of them being quite wrong. We have referred to CO_2 recorders on a good many more occasions, and we have also noticed some tests of recorders conducted at the National Physical Laboratory in 1909, which the Bulletin does not mention. These tests did not extend very far, and it is not suggested that the present investigation exhausts the subject. The question is, of course, whether manufacturers consider their instruments as sufficiently final to risk having imperfections pointed out in public. The further question is, whether the information, brought out by independent examination, about the strong and weak points of their own and of similar instruments would not in general justify taking that risk. We should like, for instance, to have the recording apparatus of Ernst Müller tested, which we described four years ago.* This instrument depends upon the heat of combination between the carbon dioxide and the potash, and measures and records the rise in temperature by the aid of a thermo-electric battery; the experience gained with the thermoscope (6) shows that reliable measurements can be made in this way.

ELECTROCHEMISTRY AND GERMANY.—The French journal *La Revue Electrique* reviews an article in the *Journal du Four Electrique et de l'Electrolyse* in which, it states, the author discusses what the part played by Germany in electrochemistry really amounts to and shows that "there is nothing to justify the incommensurable vanity of the German pedants." German discoveries do not proceed from flashes of genius, but by a work carried out methodically and, so to speak, mechanically, a work which does not make any large demand upon intelligence. When the Latin genius has given effect to new ideas, these are defaced so as to enable the taking out of patents in the name of German laboratories. Germany is allowed to say that she is at the head of the industry in question, "simply because Borchers has written volumes on the subject, because her laboratory at Aix-la-Chapelle is an admirable one and its students have inundated the technical press with their heavy compilations." The article concludes by stating that the "famous German science is simply the modern mask of the most disgraceful barbarity."

LOCOMOTIVE AND COAL TESTING AT THE ENGINEERING EXPERIMENT STATION, UNIVERSITY OF ILLINOIS.—One of the largest of the Mikado type of freight locomotives is being mounted in the locomotive testing laboratory of the Engineering Experiment Station, University of Illinois, for an extended series of tests. The Railway Engineering Experiment Station has entered into a co-operative arrangement with the International Railway Fuel Association and the United States Bureau of Mines to conduct tests with various sizes and grades of coal used for fuel. The Baltimore and Ohio Railroad has loaned one of its newest freight locomotives for the purpose. This locomotive weighs, with its tender, a total of 464,000 lb. The testing laboratory is designed to permit the locomotive to be operated at any desired speed and at any power output under the same conditions as prevail in practice, while its performance is recorded by means of automatic equipment for measuring tractive effort, water consumption, fuel consumption, smoke production, and other factors which will enter into the investigations. The Baltimore and Ohio Mikado type of freight locomotive has eight driving wheels, each carrying a load of 28,000 lb., two pony truck wheels and two trailer truck wheels. It carries a steam pressure of 190 lb. per square inch, and has a fire-box 7 ft. wide and 10 ft. long. The engine is 85 ft. long and exerts a tractive effort of 54,500 lb. at its draw-bar. Samples of coal to be used will be taken from Illinois mines and will be graded according to present commercial sizes, ranging from the so-called slack and run-of-mine up to the commonly used "2 by 6 lump." Later, it is contemplated, tests will be made with a coal ground to an impalpable powder or flour, which will be injected into the fire-box by means of a specially designed blower. Tests will be made with both hand firing and automatic stoker firing. It is the expectation that these tests will establish information which will enable a railway to determine how much it can afford to pay for the different grades and sizes of coal, and which grades and sizes will produce the best results under given operating conditions. The ultimate purpose of tests of this character which the University of Illinois is carrying on in many lines of activity is to provide the basis for the fuller and more economical utilisation of public resources. In these locomotive tests it is thought that the incidental benefits which may come to the public in the possible decrease of the smoke nuisance may alone justify the extensive work involved. The tests will be conducted under the direction of E. C. Schmidt, head of the Department of Railway Engineering, and will be in the immediate charge of J. M. Snodgrass, assistant professor of Railway Mechanical Engineering, and O. S. Beyer, first assistant in the Engineering Experiment Station.

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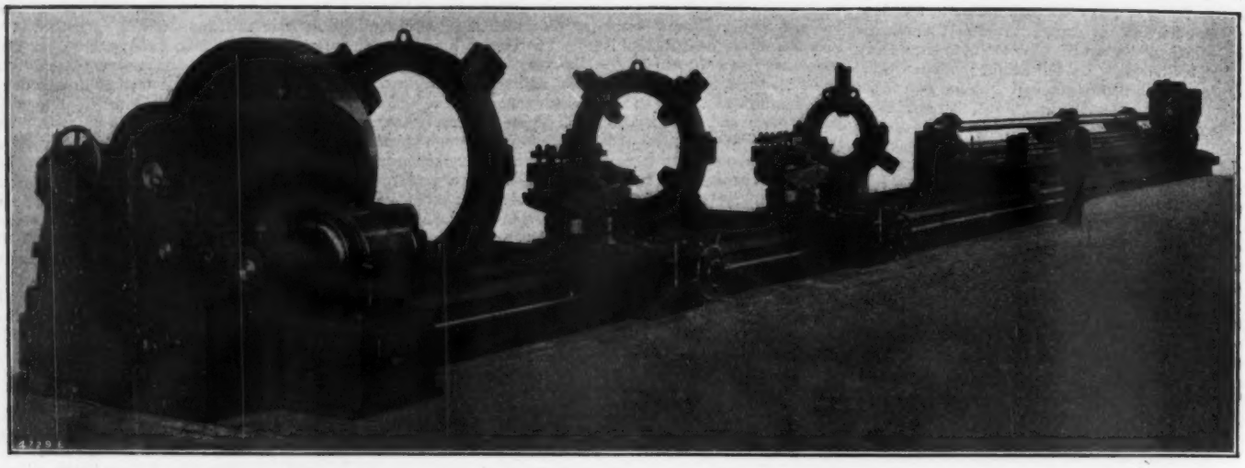
* See ENGINEERING, vol. xciii, page 569.

MACHINE TOOLS FOR MUNITION WORK.

CONSTRUCTED BY THE NILES-BEMENT-POND COMPANY, ENGINEERS, NEW YORK.



[Fig. 1. Lathe for Boring and Turning 10-In. Gun Tubes.

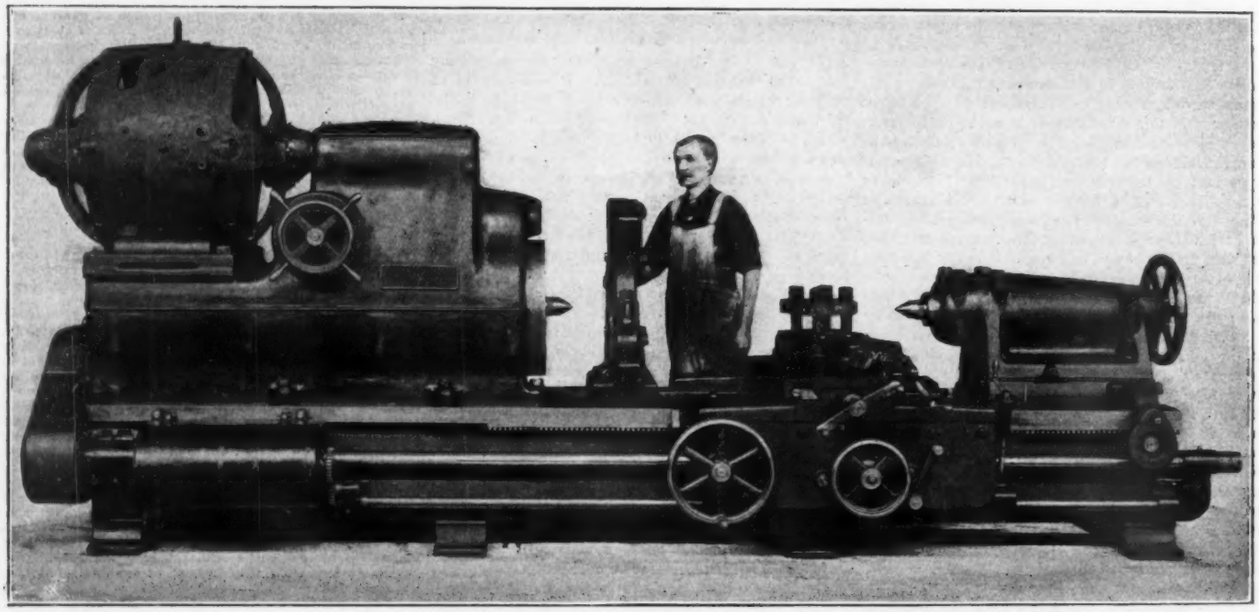


Fig. 2. 30-In. Heavy Projectile Turning Lathe.

We illustrate in the view Fig. 1 on the present page a heavy lathe built by the Niles-Bement-Pond Company, of New York, and 23 and 25, Victoria-street, Westminster, London, S.W., for boring and turning gun tubes 10 in. in calibre. The headstock is of the enclosed type, having all the driving gears running in oil. The main drive is given by a 40-h.p. variabel speed motor. Two tool holders are mounted on each of the two swivel rests; they have longitudinal traverse and also cross adjustment for setting the depth of the cut. Rapid power traverse is provided for the carriage, also for the boring bench on the bed and for the boring bar. There are three steady rests of the enclosed type. The boring bar is revolved by a separate 15-h.p. motor, mounted on the rear support. The feeds and power traverse are controlled by levers at the operator's position at the forward end of the boring bench. The boring bar has four supports—one is clamped at the front end of the bench and the other three slide on the bench with the bar. The bar is fed and traversed by means of the rear support, which engages with the feed screw. The boring bar supports have hinged caps and side extensions, so that the bar can be rolled to one side to permit the calipering and measuring of the gun's bore.

Fig. 2 shows a 30-in. heavy-projectile turning lathe built by the same company for turning armour-piercing shells up to 16 in. in calibre. The headstock is of very rigid construction, of the enclosed type; all the gears it contains are of steel, and they run continuously in oil. The faceplate is driven by a variable-speed 35-h.p. electric motor. By means of a handle on the carriage the faceplate may be started, stopped, reversed, or any of the different motor speeds can be obtained, without requiring the operator to leave his working position The motor pinion and gear which it drives have herring-bone teeth, ensuring a smooth and quiet operation. The headstock is made specially long in order to afford a most rigid support for the spindle, the gearing and the motor. The continuous oil supply to the gearing is ensured from a tank in the headstock, which is kept filled by a pump from a tank in the bed. The end thrust on the spindle is taken on hardened steel and bronze washers. The carriage is fitted with a compound swivelling tool rest; the tool slide is provided with four large clamping bolts and straps. All the parts above the carriage are of steel. The tailstock is also of extremely rigid construction, the section being considerably increased towards the end carrying the centre.

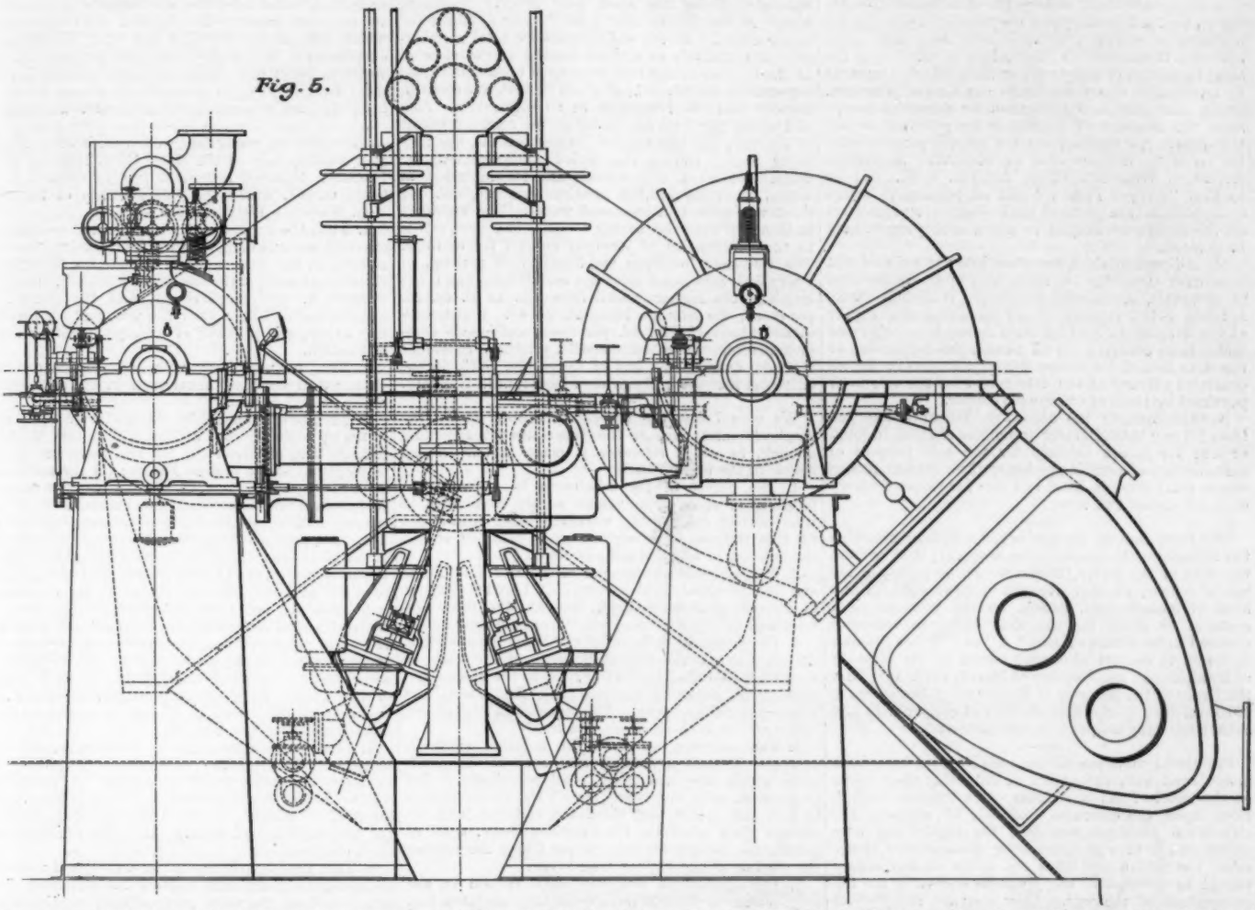
"Gas Works Directory and Statistics."—This directory for 1916–17, which is published at the price of 10*s.* 6*d.* net by Messrs. Hazell, Watson and Viney, Limited, 52, Long Acre, W.C., is the thirty-ninth issue. It contains an alphabetical list of officials, together with data also arranged alphabetically, according to towns, of the gas works in England, Wales, Scotland, Ireland, the Colonies and foreign countries, the information including the date of formation of the undertaking, quantity of coal carbonised, annual make and sale of gas process, residual make, &c. The book covers over 550 clearly printed pages, in double column.

United States Steel Corporation.—The business of this undertaking has experienced a remarkable increase this year. In January, February and March the net earnings were 60,713,624 dols., as compared with 51,232,788 dols. in the corresponding period of 1915 and 12,457,800 dols. in the corresponding period of 1914. In April, May and June the net earnings were 81,126,048 dols., as compared with 27,950,055 dols. and 20,457,596 dols. July, August and September produced a net revenue of 85,817,067 dols., as compared with 38,710,644 dols. and 22,276,002 dols. The aggregate net revenue for the first three quarters of this year was accordingly 227,656,739 dols., as compared with 79,118,500 dols. in the corresponding nine months of 1915, and 60,727,978 dols. in the corresponding nine months of 1914.

GEARED TURBINE INSTALLATION FOR THE S.S. "CITY OF CANTON."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

Fig. 5.



THE increasing favour with which geared turbines are regarded even for low-speed cargo steamers using steam superheated to a moderate degree is due to the high economy and great reliability of the machinery. The steam consumption for all purposes has been as low as 12.5 lb. per shaft-horse-power hour in actual service, and in space occupied and wages for personnel satisfactory financial results are realised. Over 50 ships are now in course of construction with such installations, and many of the latter are for driving single screws. The Wallsend Slipway and Engineering Company, Limited, has done much in advancing the adoption of such machinery, Mr. Andrew Laing, the managing director, having in this, as in other engines, adopted standardisation as far as is possible.

The drawings of the geared turbines for a single-screw installation which we reproduce on this page and on Plate XLVII, and the general arrangement drawings which we intend to give later, will therefore prove interesting. They represent the installation of 3,350 shaft horse-power in service for the City of Canton, a vessel of 6692 tons gross register, built by Messrs. Swan, Hunter and Wigham Richardson, Limited, Wallsend-on-Tyne, for the Ellerman Line, Limited, Liverpool; but several such sets of machinery are being constructed for other ships requiring the same power.

As is shown in the plan, Fig. 2, on Plate XLVII, and in the end view, Fig. 5, annexed, the high-pressure and low-pressure turbines work in series normally, and drive through their respective pinions one gear wheel connected to the propeller shaft, but each turbine can take steam direct from the boiler, and each has an astern turbine working on the same pinion. Thus, so far as the propelling engines are concerned, there are the advantages of duplication against the contingency of one turbine breaking down. The turbines transmit their power through flexible couplings to the pinion shafts, the pinions being arranged one on each side of the gear wheel. The main shaft of the gear wheel is provided with a solid flanged coupling which is directly connected to the thrust shaft. The reduction ratio is 1 to 17. The longitudinal half-sections of the two turbines in Figs. 3 and 4, on Plate XLVII, show that the astern high-pressure turbine is arranged with an independent casing at the forward end of the ahead high-pressure turbine, being connected to the latter through a flanged coupling. The low-pressure astern-going turbine is incorporated in the exhaust end of the low-pressure ahead-going turbine casing.

In order to deal effectively with the high-pressure superheated steam—125 deg. F.—which the boilers are arranged to supply, the turbines, which are of the Parsons type, have been designed on the impulse-reaction principle, with an impulse wheel forming the initial stages in the high-pressure ahead and the high-pressure astern-going turbines. The low-pressure turbines, both for ahead and astern going, consist entirely of stages of reaction blading. The use of superheated steam has also necessitated the use of materials not ordinarily used in the construction of marine turbine machinery. The turbine casings, generally made throughout of cast iron, have been in this case partially made of cast steel. The steam admission end of the high-pressure ahead turbine casing has been made in this metal, while the whole of the high-pressure astern turbine casing is of cast steel. The blading of the impulse wheels, as also the earlier stages of reaction blading, have been made of copper material instead of the usual brass mixture, the copper withstanding the action of the superheated steam much better. The rotating portions of the turbines—the bodies of the rotors and the spindles—have been made entirely from ingot steel forgings.

The gearing is of the double helical type, the shape, size and pitch of the teeth being made in accordance with what experience has proved to be satisfactory. The large gear wheel is divided vertically, and each section of the wheel, consisting of boss, sides and rim, is cast in one piece, flanges being provided on the boss for bolting them together. Near the rim a circumferential tie-piece of cast steel is provided with flange connections to the wheel sections. Heavy forged steel rims on which the teeth are cut are shrunk on and secured to the cast-steel portions.

The distance apart of the two sections of the rim is sufficient to allow of central bearings being fitted to the pinion shafts, as shown in Fig. 3, to preserve the alignment. The gear-wheel shaft is of forged ingot steel, while the pinions and shafts are of nickel steel.

For the efficient and silent running of this gearing it is necessary that the means of lubrication should be as thorough as possible. For this purpose sprayer nozzles distributed at suitable intervals are arranged to spray the oil direct on to the engaging teeth, thereby providing a film of oil between the surfaces in contact. The bearings for the turbine spindles, together with the bearings of the gear-wheel and pinion shafts, are also arranged to work under a system of forced lubrication.

In the arrangement of machinery it was found possible, as shown in Figs. 1, 2 and 5, to place the condenser at a low level, and at the same time quite close to the low-pressure turbine; this assists the drainage problem and also does away with the usual overhead exhaust connection. The condensers are of the Weir uniflux type, made suitable for 27½ in. of vacuum in ordinary service conditions with the temperature of sea water at 85 degs. For circulating water through the main condenser a pump of the centrifugal type is provided. This pump is driven by a single-cylinder open engine, and the pump and engine have been supplied by Messrs. Drysdale and Co., Limited, Glasgow. An air pump of the dual type, supplied by Messrs. G. and J. Weir, Limited, is fitted to work in conjunction with the condenser. The air pump is of the merchant service type, having gunmetal pump barrels with cast-iron bases and tops, fitted with gunmetal buckets, manganese bronze pump rods, steel piston rods and Kinghorn valves in gunmetal seats. In our next article we shall deal with the general arrangement of the machinery and with the auxiliaries.

(To be continued.)

SPANISH MINING.—The mining industry in Spain has acquired more importance than is generally known. The output of iron ore in 1915 was 5,617,839 tons. Pyrites were raised to the extent of 730,568 tons; iron ore briquettes to the extent of 555,357 tons; and manganese ore to the extent of 14,328 tons.

INDUSTRIAL NOTES.

The Press Bureau has issued a circular to the effect that the Minister of Munitions has ordered the following :—

1. No person shall, as from the date hereof (December 8), buy, sell or, except for the purpose of carrying out contract in writing existing prior to such date, enter into any transaction or negotiation in relation to the sale or purchase of copper of any class, whether wrought or unwrought, situated outside the United Kingdom, unless such person is authorised by a special permit from the Minister of Munitions to purchase or sell the same. All applications for special permits shall be made to the Director of Materials, Armament Buildings, Whitehall Place, London, S.W., and be marked "Copper Permit," and all persons to whom such permits are granted shall observe and perform all the conditions subject to which such permits may be granted.

2. All persons shall, except as below mentioned, not later than December 16, 1916, send in to the Director of Materials, Armament Buildings, Whitehall Place, London, S.W., returns of (*a*) all unwrought copper at the date hereof held by them in stock or otherwise under their control; (*b*) all unwrought copper due at the date hereof for future delivery to them; (*c*) all contracts existing at the date hereof for the sale to or purchase by them of unwrought copper.

Notwithstanding the above, no return is required from (1) any manufacturer or smelter of stock in hand or due for future delivery for the sole purpose of manufacture or smelting at his works; (2) any person whose total stock in hand and due for future delivery does not exceed two tons.

The Press Bureau has also issued a circular by which the Minister of Munitions gives notice (1) that as from the date of the Order (December 8), he prohibits the use of copper, whether wrought or unwrought, in any kind of manufacture, except for the purposes of a contract or order for the time being in existence certified to be within Classes "A" or "B" of Circular L. 33 as to control of output issued by the Minister of Munitions on the 31st day of March, 1916. (2) That the Order of the Minister of Munitions of November 6, 1916, relating to the manufacture of copper wire and cable containing copper is hereby cancelled.

Prominent members of the metal trades have been interviewed with the object of obtaining their views on the effect of the new Order which imposes restrictions upon the purchase and sale of copper. The impression gathered was that the regulations were made with a view to preventing non-essential trades using the metal, and that the whole of the supply should be devoted to the purposes necessary for the prosecution of the war. They instance many cases where copper and brass are being used, and where labour is also being employed which might be devoted to war purposes (such industries as those manufacturing brass bedsteads, household fixtures, electric light fittings, &c.). The effect of the Order will be that these trades—due to the fact that they will be unable to obtain copper without a licence—will release a large number of men and women, and it will also have the effect of economising the metal. It is well known that the Government have practically covered their own and the Allied Governments' copper requirements for many months to come, and in all probability the end to which the Government directs its attention in this Order is mainly the economy of labour. It is very satisfactory to note that great economies have recently been effected in the use of metals for munition purposes, and, in fact, the Metal Committee, which is at present devoting its time to this very important subject, is confident in the near future of making further enormous reductions in the use of copper, brass and other more expensive metals.

It is only natural to suppose, when such large quantities of copper are available for the British and Allied Governments as compared with the copper resources of the enemy, that there must be great scope for economy, and that with the very large supplies hitherto coming forward it is not perhaps to be wondered at that the designers of war material, or materials for industrial purposes, have not sooner followed the lines of economical alteration and substitution which undoubtedly the enemy have been carrying out. It is well known that there is an organisation whereby spent cartridges are returned from the front and re-used, re-formed in some cases, or re-melted.

All these economies will obviously have considerable effect in reducing the requirements of the more valuable metals.

In his report for November the general secretary of the United Patternmakers' Association says he has received, after a somewhat lengthy interval, the June and July numbers of the *International Metal Workers' Review*, a publication in English issued from Stuttgart. According to this review, the German Metal Workers' Union appear to be having a bad time; 117,180 of their members had been summoned to the colours during 1915, and an additional 70,000 left for various reasons; during the same year 109,573 (including about 20,000 females and 8,000 juveniles) joined the organisation. At the end of 1915 the total membership was 234,307, as against 544,934 at the close of 1913. Income during 1915 amounted to 439,907*l.*, and expenditure to 185,030*l.*, of which 61,634*l.* was spent in benefits and the remainder in administration. Sick and strike pay were suspended at the commencement of the war, but one-half the former benefits was now being paid. During the period under review the union conducted 615 movements for increases in wages, involving 176,381 members, and 24,706*l.* per week was gained in increased wages. The moulders in Hungary were also having a rather bad time, owing to the substitution of stamped articles for castings. The Budapest foundries employed 2,068 persons, of whom 583 were hand moulders and 200 females; the wages of the former ranged from 25*s.* to 3*l.* 6*s.* 8*d.* per week, the average being 2*l.* 3*s.* 4*d.* Coremakers earned about 1*l.* 12*s.* 6*d.* per week, and female coremakers received on the average 3*d.* per hour. Reference is made, even at the end of December, 1915, to the enormous increase in the price of foodstuffs in Hungary.

We give below the agreement drawn up by the employers and men in the Wear district regarding pooling, to which reference is made in our leading article in the present issue :—

1. The object of the scheme is to expedite the finishing of such cargo vessels as are from time to time nearest completion, workmen being transferred for that purpose from work in other yards on vessels the building of which is less advanced.

2. The senior local surveyor of the Board of Trade and the principal local surveyor of Lloyd's Register of Shipping shall determine in their absolute discretion from time to time the vessel which is nearest completion.

3. The technical delegate of the Wear Shipbuilders' Association and the district delegate of the trade or trades affected shall then arrange as to the classes and number of workmen required and the yards from which they can be drawn. The consent of the workmen to transfer shall be obtained in each case.

4. The selection of workmen required shall be arranged in such a manner that each of the yards from which they are taken shall contribute a fair proportion, with due regard to all the circumstances in each case, but so that they shall be taken from the nearest yards available, the intention being, as far as practicable, to transfer men whose homes are nearest the yard to which they are transferred.

5. The transferred workmen shall remain in the employment of the firm from which they are taken and their wages shall be paid by that firm and they shall return to their work in the yard of that firm as soon as the purpose for which they have been transferred has been accomplished.

6. The workmen who are transferred shall not suffer any pecuniary loss by reason of their transfer.

7. The firm concerned shall utilise on the vessel selected for speedy completion the whole of the workmen of the class required in their employ before any men are transferred from other yards.

8. Urgent Admiralty requirements shall take precedence of this scheme.

9. This scheme shall remain in effect for the duration of the war.

In the course of his presidential address, delivered on Wednesday, November 22, before the Boat, Yacht and Allied Trades Association, Mr. William Summers, M.Inst.N.A., said the association wanted to popularise the trade, and had asked the Shipwrights' Society to appoint a committee to confer with it in regard to arriving at the best form of indenture for apprentices. Ships' wooden lifeboats, he added, were also a matter which had been largely discussed by the association and the committee of the Scottish branch. Subcommittees had met in Newcastle, Glasgow and London. The subject was of the greatest importance, and the association had asked the Shipwrights' Society to appoint delegates to a joint committee for its consideration. He advocated the standardisation of ship's lifeboats.

At a meeting of the West of Scotland Iron and Steel Institute, held in the Technical College, Glasgow, on the 8th inst., the president, Mr. Herbert Beard, referred to the way in which we had organised to the full our military and labour resources during the war. Industry, in fact, had been organised on a scale and with a speed and ability which were both a wonder to other nations and a testimony to the inherent quality of our race. But the remarkable organisation which had taken place had not been without defects. It had been responsible for a prodigal waste of public money; the situation had, however, to be faced, and if the thing had to be done again it might perhaps be done no better. The State was paying dear for everything it required. Swollen profits had been made; wages had advanced 70 per cent. in the iron and steel trades since the war began and were likely to go even higher. He blamed the opportunities which offered for frivolity and the indulgence in amusements, and stated that the payment of high wages to immature youths had been productive of the most baneful results; compulsory saving should be instituted and measures taken to enforce discipline.

The following resolutions were unanimously adopted at a meeting held at the Hotel Cecil, London, on the 7th inst., between representatives of employers and trade unions, under the chairmanship of the Right Hon. Frederick Huth Jackson :—

1. That the cordial and whole-hearted co-operation of employers and employed will be the most important element in the success of any scheme for dealing with the reinstatement of the men of the Forces and munition workers in civil employment, and the general redistribution of labour after the war, and for handling any subsequent problem of unemployment or labour dislocation.

2. That no machinery now in existence can adequately deal with the reinstatement in civil employment of the present Forces.

3. That powers should be obtained from Parliament to set up without delay a Central Statutory Board to regulate and supervise (*a*) the reinstatement in civil employment of the present Forces; (*b*) the settlement in normal employment of civilian workers now in Government or controlled establishments; (*c*) any general redistribution of labour arising out of the war. Appropriate transfers of existing powers and duties will have to be made by the various Government Departments to the Central Statutory Board, so that complete authority shall be vested in the new board.

4. That not less than two-thirds of the members of this Central Statutory Board should be representatives of employers and employed in equal numbers, such members being appointed by the Crown from associations of employers and from the trade unions of the United Kingdom respectively, the remaining members of the board to include representatives of Government Departments, &c.

5. That where a trade union, by arrangement with employers' associations, is capable of placing its members in employment, it should be competent for the Central Board, if it deems it to be in the national interest, to delegate to the trade union in question the responsibility of dealing with the reinstatement of its own members.

6. That local boards should be established wherever necessary to assist the Central Board. Such local boards to have the same proportionate representation as is provided for the Central Board.

7. All expenses properly incurred by the Central and local boards should be paid out of moneys provided by Parliament.

"Manual of Electrical Undertakings and Directory."—We have received a copy of this manual —Garcke's—for 1916–17, vol. xx, which is issued by the Electrical Press, Limited, 13 to 16, Fisher-street, Southampton-row, at the price of 21*s.* net. In sending us this volume, the editors state that one unavoidable result of war conditions has been delay in the issue beyond the customary date, but advantage has been taken of the extended period to include accounts and particulars to a later date than was possible in former volumes. The present edition includes over 20,000 names and addresses of officials connected with electrical undertakings, members of tramway and lighting committees, electrical contractors and electrical engineers in general. In regard to companies and corporations, the information gives technical and financial data, prices, results obtained, &c. The book contains numerous maps of electricity supply undertakings, tramways and railways, also a map of Great Britain showing the electric undertakings in operation.

British Capital in Canada.—The flow of British capital to Canada has been on a considerable scale during the last ten years, although a sharp contraction was experienced in 1915 and 1916. The yearly totals come out as follow :—

Year.	Amounts. £	Year.	Amounts. £
1907	11,203,711	1912	32,456,600
1908	20,354,721	1913	47,363,426
1909	37,411,723	1914	37,777,271
1910	38,453,808	1915	8,325,000
1911	30,855,517	1916	1,000,000

The war rapidly reduced the volume of British-Canadian investments, which during the past twelve months have been almost at an end. It will be seen that the record year was 1913; in the last five months of 1914 the war greatly restricted Canadian investments, which were further reduced in 1915. The aggregate investments of British capital in Canada are estimated at present at 582,829,000*l.* At the close of 1913 American capital had also been placed in Canada to the extent of 636,903,952*l.*

EXPERIMENTS ON EARTH-PRESSURES.*

By PONSONBY MOORE CROSTHWAITE, B.A.I., M.Inst.C.E.

THE paper commences with a short account of Rankine's theory of earth-pressure, and the principles and assumption on which it is founded. Descriptions of former investigations are given in some detail, namely, those of the late Sir George Darwin, and Messrs. Goodrich, Wilson, Bell and Meem. The author concludes that of the experiments made by these investigators to investigate the lateral pressure of earth, those in which model walls were used are of greatest value, but points out that if models are of any size the experimental difficulties are almost insuperable.

The author's experiments, a number of which are described and illustrated in the paper, were made by loading a plunger with known weights and measuring the penetration when the plunger had come to rest after the application of each weight. The materials were enclosed in an open bucket, and their weight was determined.

With those data the value of ϕ, the angle of internal friction, can be obtained from Rankine's well-known formula for the safe depth of foundations—

$$d = \frac{P}{W}\left(\frac{1 - \sin\phi}{1 + \sin\phi}\right)^2$$

when d denotes the penetration; P the pressure in pounds per square foot; and W the weight of the material in pounds per cubic foot.

If the formula is true, and the pressures be plotted against the penetrations, the resulting curve is a straight line, and ϕ as calculated from the formula should equal the angle of repose.

With sand, garden earth, and cinders and ashes the resulting curves are straight lines, but it was found that the value of ϕ varied with the state of aggregation of the material, *i.e.*, whether it was lightly poured into the bucket, shaken in, or well pounded in. When the material was deposited in the bucket as lightly as possible the angle of internal friction was the same as the angle of repose, but with more consolidation the angle was much greater.

From these materials the author concludes that Rankine's theory holds, provided the proper angle of internal friction is used and not the angle of repose. If, however, this angle is used it would be necessary to introduce a factor of safety into the formula, for a wall designed without one would be theoretically just strong enough and no more. In Rankine's formula there is no factor of safety, and it is concluded that Rankine saw this, and used the angle of repose as covering the worst conditions that need possibly be provided for. The author's experiments show that, for the materials tested, work designed by Rankine's formula, using the angle of repose, would have a factor of safety of 2½ to 4, and he considers that these are not unreasonable figures for such materials.

The experiments on clay give altogether different results, for instead of the penetration varying as the load, it varies as the square of the load, and the penetration curves are parabolas. These results, which were altogether unexpected, are completely confirmed by larger experiments carried out by Messrs. Coode, Matthews, Fitzmaurice and Wilson, and by Mr. McAlpine in New York.

The author is able to give no physical explanation as to why the penetration in clay should vary as the square of the load, but leaves it to the physicists. The law must be capable of some rational explanation, and, if true, it upsets all earth-pressure theories when they are applied to clay; for all accepted theories assume that the angle of internal friction is the same as the angle of repose, and that its value is independent of the pressure.

It is suggested that the subject is worthy of further investigation, but that such could hardly be made by a private individual, for the work is tedious, each experiment taking from 24 to 48 hours. Moreover, if the investigation is to be properly carried out, physical and chemical analyses of the clays will be required that could only be made in a well-equipped physical laboratory.

In connection with the earth slides experienced at the Panama Canal, it has been suggested that in clay and shale cuttings there is a critical depth beyond which the sides will not stand, and the author's experiments on clays clearly show that for these this must be the case. Where ϕ is independent of the pressure the depth of the cutting cannot affect the stability of the slope, but where the angle decreases with the pressure it is evident that eventually a depth will be reached beyond which its sides will not stand.

This decrease is clearly shown in one experiment on mud, for which the angle for a pressure of 0.25 ton per square foot was 17 deg. 15 min., which decreased to 2 deg. 10 min. at a pressure of 1.25 ton per square foot, when it was little better than a liquid.

THE VEREIN DEUTSCHER INGENIEURE.—The number of members of the Verein Deutscher Ingenieure, which held its annual meeting on November 27, in Berlin, has decreased during the year 1915. At the end of 1914 the total membership of the many branches was 24,725; there died during 1915, 401 (385 in 1914), and resigned, 356 (224), whilst 287 new members (1,214) were enrolled; the total roll for 1915 was thus 24,255. During the year 380 members were killed; 3,567 members remain on active service.

* Abstract of a paper read before the Institution of Civil Engineers, Tuesday, December 5, 1916.

SALVAGE EQUIPMENT USED IN RAISING SUBMARINE F-4., U.S.N.*

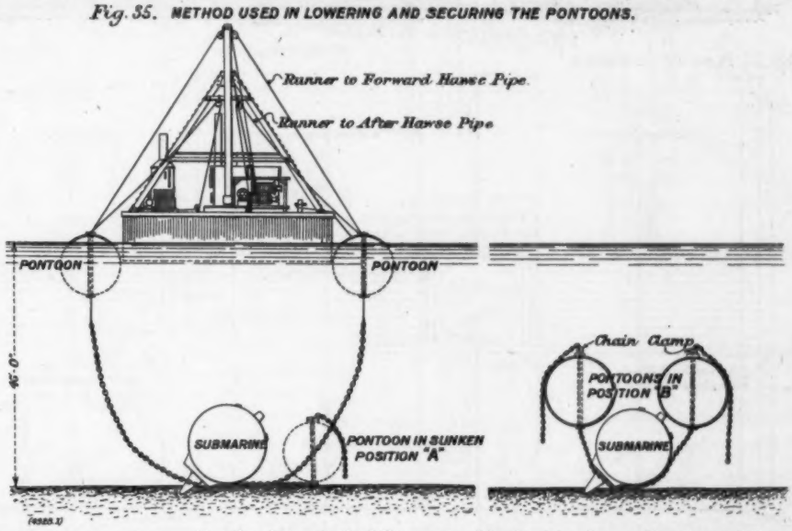
By NAVAL CONSTRUCTOR J. A. FURER, U.S.N., Member.

(*Concluded from page 571.*)

Placing the Pontoons.—After all the chains had been laid out on the bottom under the vessel the barge was shifted for landing the midship pontoons. These were flooded to about 3 ft. of freeboard in the harbour before being towed out to the job. One pontoon was placed on each side of the barge opposite the A-frame, as shown in Fig. 35 below. The four runners from the engine drums were dropped through the hawse pipes (Fig. 36, page 584), to the bottom and a report made by the divers on their location with reference to the chains. When the position was reported as satisfactory, the runners were shackled to the ends of the chains. In the meantime flooding the pontoons was continued.

A 50-ft. length of pneumatic hose, fitted with a ¾-in. valve at the end, was connected to each vent (Fig. 37, page 584, and Fig. 49, page 585). By manipulating these valves the trim of the pontoons was kept under control. The flooding valves P (Fig. 36, and Figs. 50 and 51) were left open. As soon as the runners had been dropped through the hawse pipes and shackled on below, the clamps were placed on top of the castings, as shown in Fig. 3, page 560 *ante*. In order to facilitate the work of the divers in bringing the two halves of the clamps together, loosely fitting ¾-in. guide bolts were passed through holes provided for that purpose in the ends of the clamp castings (Figs. 41 to 47). These bolts were long enough to permit spreading the clamps to the full 12-in. diameter of the hawse pipes. The clamps were lashed to the running boards of the pontoons to keep them from slipping off.

Fig. 35. METHOD USED IN LOWERING AND SECURING THE PONTOONS.



Five-inch manila lines were made fast to the end pads of the cylinders. The forward line of each pontoon was taken to a timber head and the after-line to the niggerhead of one of the hoisting engines. These lines were marked every 5 ft. as a guide for lowering.

When everything was in readiness, the final flooding of one of the pontoons was started. As soon as the pontoons showed a tendency to sink, the vents were shut off to avoid further increase in negative buoyancy. Any slight excess of water in one compartment had the effect of making that end go down first and cockbilling the pontoon. The object of the lowering lines was to prevent the cylinders from sinking end on, as would invariably have happened without such control. As soon as the divers reported that a cylinder was lying squarely on the bottom, parallel and close to the submarine, the vents were opened for complete flooding. In the case of one pontoon one end had to be lifted and swung in closer to the vessel. This would have been difficult had the pontoon been completely filled with water before the adjustment was attempted. The flooding valves were closed after the pontoons had filled completely, in order to prevent the entrance of sand.

Although the negative buoyancy was kept well in hand by careful venting, the cylinders nevertheless showed a decided tendency to become unmanageable and heavy as soon as the water-plane area had vanished. All of the pontoons were, however, lowered without mishap and without parting lines.

The divers began bolting on the clamps as soon as the position of a cylinder was reported as satisfactory. It was not essential that the clamps for the first lowered pontoon of a pair should be fitted to any particular link, but, once fitted, it was necessary to know exactly the link on which each was placed so that the clamps on the opposite side might be placed correctly, this in order to insure that the proposed amount of slack was left in each chain. If the chains had been hauled up snugly and the clamps had been placed directly above the hawse pipes, the pontoons would have been held down alongside the submarine on becoming buoyant. This would have brought a considerable crushing stress on the sides and would have been particularly objectionable because of the excessive stress to which the chains would have been subjected.

Unwatering the Pontoons.—After considering various methods of unwatering the pontoons, the use of compressed air taken from torpedo air flasks was decided upon as the simplest and most reliable method. Calculations indicated that 20 torpedo air flasks blown down from 2,150 to 200 lb. pressure would furnish enough air to raise the vessel. In order to maintain a rapid flow of air from the flasks it was proposed to blow down to only 200 lb. Tests were made which demonstrated that a flask could be blown safely from 2,150 to 200 lb. pressure in about 5 minutes against a receiver pressure of 50 lb. A test was also made on the flow of air through a 150-ft. length of ¾-in. hose, using a differential pressure of 25 lb. per square inch. From this test it was found that the flow was considerably greater than given either by Halsey's or Kent's formulæ. On the basis that the air would be delivered to the pontoons by 12 150-ft. lengths of ¾-in. hose against a water head of 46 ft. and with a differential pressure of 20 lb., it was calculated that the cylinders could be unwatered in about 100 minutes. When this stage of the work was actually reached, the differential pressure was kept somewhat below 20 lb. as a precaution against starting the seams of the end bulkheads of the pontoons. The cylinders were actually unwatered in about two hours after air was fully turned on.

Twenty-four torpedo air flasks were installed on a coal barge, as shown in Fig. 6, page 560 *ante*. These flasks were connected in parallel to a 7-in. extra-heavy pipe. This pipe discharged into an expansion chamber made from a piece of cast-iron pipe 22 in. in diameter by 8 ft. long. The expansion chamber was piped to a 12-valve manifold, to which the pneumatic hose lines leading to the pontoons were attached. A gauge was installed on the 7-in. pipe, as well as on the valve manifold.

The 7-in. extra-heavy pipe was necessary so that if any one of the valves from the flasks should happen to blow through, the full pressure would not be thrown on the large expansion chamber and on the hose leads. This arrangement also made it possible to throw in a new flask by simply opening a valve. The pressure at the hose manifold was kept at 35 lb. until the cylinders emerged. By throttling the flask valve and the valve in the line to the expansion chamber, this pressure was maintained without difficulty.

Final Salvage Operations.—The work of passing the chains under the vessel was not started until the pontoons and all the collateral equipment needed had been made ready. It took three working days to place the chains, with a few intervening days when the swell and undertow were so heavy that divers could not stay on the bottom. The three pairs of pontoons were placed on three successive days. The job of substituting the coal lighter, with its equipment of air flasks, for the wrecking barge was completed on Saturday, August 28, too late to unwater the pontoons on that date. This work could not be done with certainty at night.

Fortunately the weather held good through the night. The final work of connecting up the hose leads to the pontoons and opening the discharge and blow valves was started at daybreak on Sunday, August 29. This work was left until the morning, as it would have been inadvisable to subject the twelve 150-ft. lengths of hose to the action of the swell during the night.

When all necessary preparations had been made, a diver was sent down to watch the pontoons and to report by telephone as they became buoyant. The air was first started on all four compartments of the stern pontoons. When this pair was buoyant the air

* Paper read at the 24th general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17, 1916.

SALVAGE EQUIPMENT USED IN RAISING SUBMARINE F-4, U.S.N.

Fig. 36. LONGITUDINAL SECTION THROUGH CYLINDER.

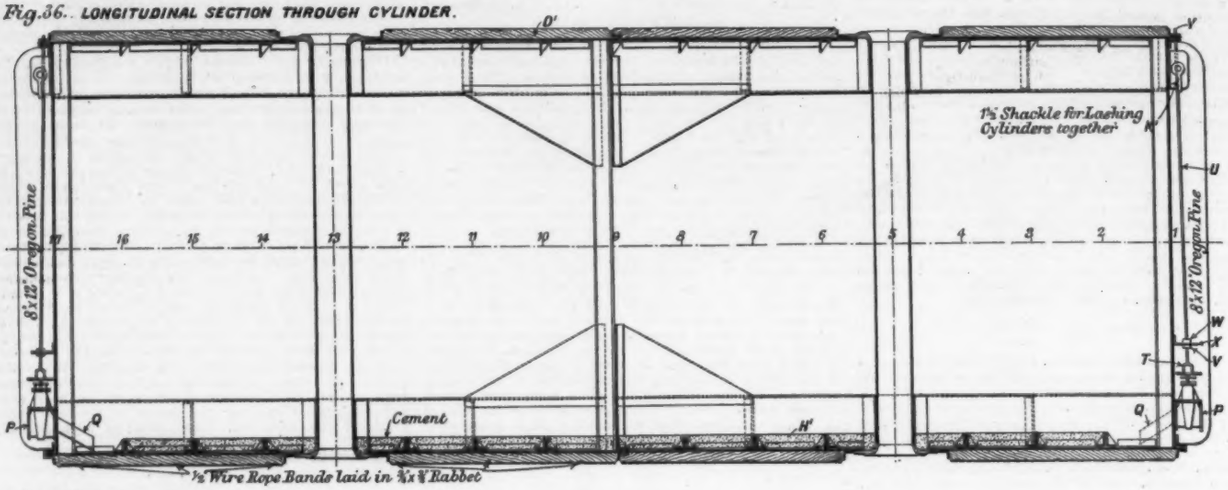


Fig. 37. PLAN OF CYLINDER.

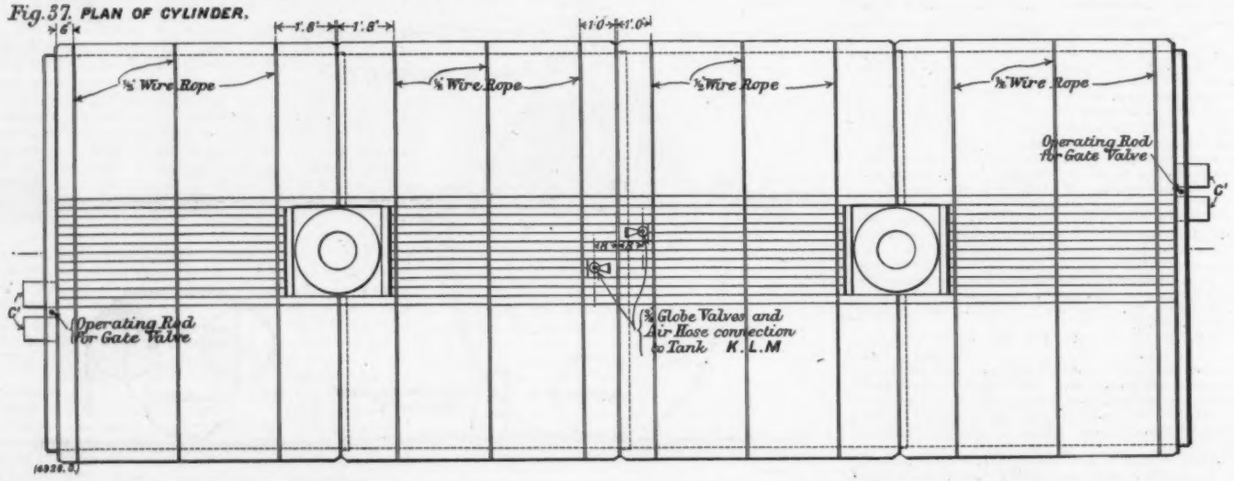


Fig. 38. SECTION IN WAY OF WIRE ROPE BAND.

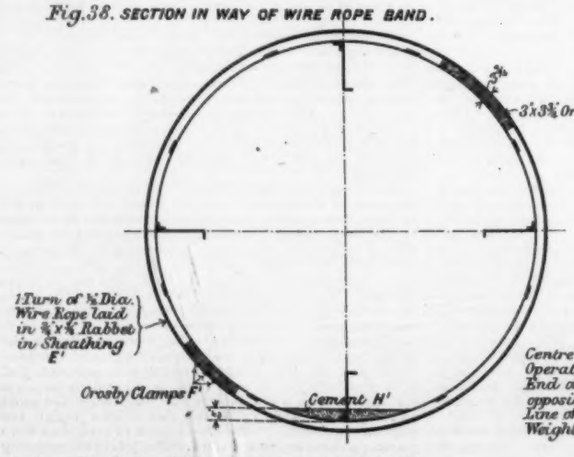
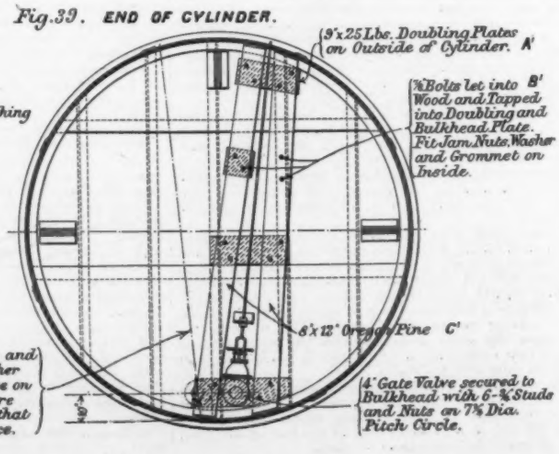


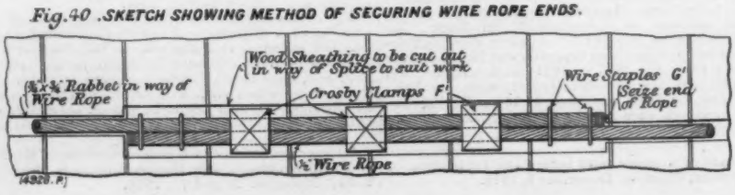
Fig. 39. END OF CYLINDER.


9"x25 Lbs. Doubling Plates on Outside of Cylinder. A'
¾" Bolts let into B' Wood and Tapped into Doubling and Bulkhead Plate. Fit Jam Nuts, Washer and Grommet on Inside.
8"x12" Oregon Pine C'
Centre Line of Valve and Operating Rod on other End of Cylinder to be on opposite Side of Centre Line of Bulkhead so that Weights will Balance.
4" Gate Valve secured to Bulkhead with 6-¾" Studs and Nuts on 7" Dia. Pitch Circle.

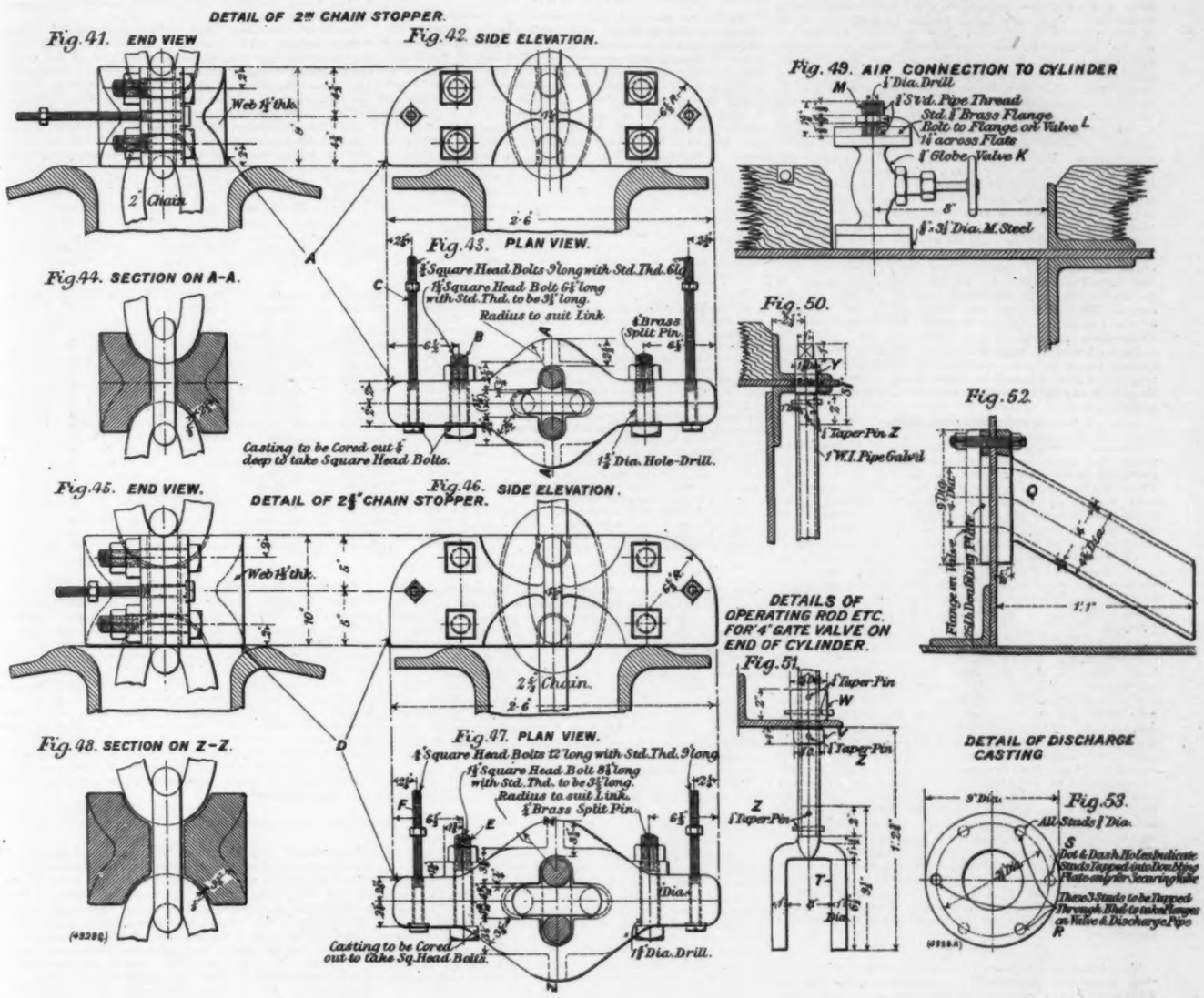
was shut off and the middle pontoons were started off the bottom in the same manner. In the case of the bow pontoons it was necessary to bring the forward end of the seaward cylinder off the bottom in advance of the after-end in order to clear the bow rudder on this side, which was still in place and projected upward at an angle of about 45 deg. If this precaution had not been taken the pontoon would have jammed against the sharp point of the rudder and would probably have sprung a leak. The pontoons were all partly unwatered before turning on the air to all six cylinders, in order to make certain that all the lines and discharge valves were functioning properly.

When the pontoons had in turn been brought to a reasonably horizontal position by manipulating the manifold valves, air was turned on to all twelve

Fig. 40. SKETCH SHOWING METHOD OF SECURING WIRE ROPE ENDS.


¾"x¾" Rabbet in way of Wire Rope
Wood Sheathing to be cut out in way of Splice to suit work
Crosby Clamps F'
Wire Staples G' Seize end of Rope
½" Wire Rope
(4929. F.)

SALVAGE EQUIPMENT USED IN RAISING SUBMARINE F-4, U.S.N.



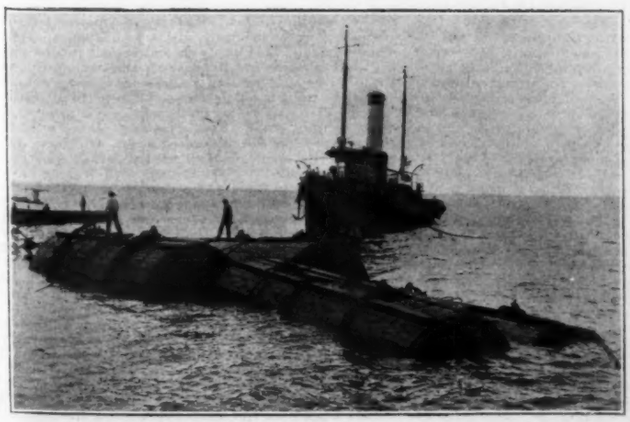


FIG. 54. ALL PONTOONS ON THE SURFACE; MAKING PREPARATIONS TO TOW SUBMARINE INTO THE HARBOUR.

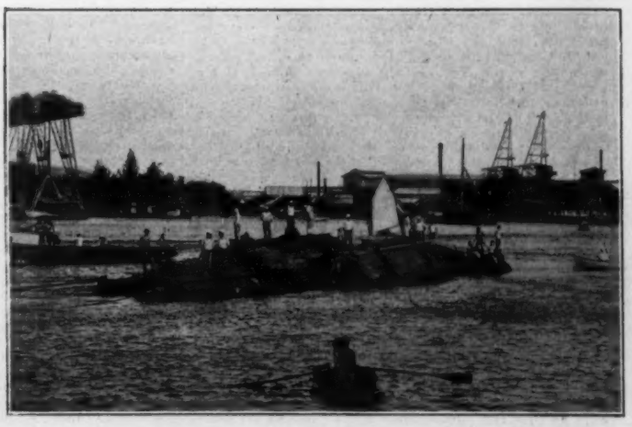


FIG. 55. TOWING THE F-4 INTO PORT, SUSPENDED FROM THE PONTOONS.

compartments. One end of the submarine came up slightly ahead of the other, as was inevitable. It was noted that one of the pontoons was still considerably cockbilled. This condition existed in the case of all of the pontoons until they had adjusted themselves on the surface, because the chains were rove under the vessel from the pontoon on one side to its mate on the other side without being attached to the submarine. One end of each pontoon was bound to become buoyant slightly ahead of the other, also the two pontoons of a pair could not be manipulated so as to bring them buoyant simultaneously. As a small amount of slack was intentionally left in each chain, the pontoon which became buoyant first pulled the slack through under the vessel. This resulted in cockbilling the pontoons while they were completely submerged. So long as there was a sufficient amount of margin of buoyancy in all six pontoons the cockbilling was not of great importance, as enough water could be blown out of the high ends to provide the lift needed. The low ends could, of course, be completely unwatered. Once the pontoons emerged they immediately adjusted themselves automatically, as the high ends ceased to be waterborne and therefore exerted no pull on the chain. This permitted the buoyancy of the low end of the opposite pontoon to assert itself, thus causing the chain to render.

Figs. 54 and 55, page 585, show the pontoons on the surface ready to be towed into the harbour, with their suspended load. It will be noted from these views that they have adjusted themselves to practically a horizontal position.

German Submarines.—The Italian *Rivista Marittima* states that according to news received from Holland the Germans have built submarines having no periscope. There is a lens on each side of the boat, which, combined with mirrors and other lenses properly arranged, make it possible to carry out the necessary observations. It is admitted that this improvement carries with it the disadvantage of requiring the boat to navigate closer to the surface than is the case with boats provided with a periscope, but this disadvantage is more than compensated for, so it is said, by the absence of a periscope tube extending above the water surface. A powerful beam of light can be projected at night through the lens opening.

Controlled Establishments and Secrecy.—We have received the following official notification for publication:—The Minister of Munitions appeals to the owners of controlled establishments, to all persons responsible for the management of such establishments, and to the public generally, to guard against communicating to neutral countries information concerning controlled establishments, the effects of control on the conduct of their business, and the character and quality of munitions work in hand. Such information is sometimes conveyed (probably by inadvertence) in replies to inquiries as to whether particular establishments are able to undertake particular classes of work, and also in advertisements in newspapers which circulate abroad. The public are warned that no communications of any kind can be transmitted abroad (1) if they give any indication that a firm is controlled or is engaged in munitions work, or (2) if they contain information with respect to the manufacture, output, or supply of munitions, or with respect to the place where such work is carried on.

The Proposed Goods Clearing House.—*The Railway News* has published a pamphlet criticising the proposed goods clearing house for the metropolis advocated by Mr. Gattie. This pamphlet is entitled "Some Railway Myths and Fallacies," and deals with such subjects as "Mobility *versus* User of Railway Wagons," "Alleged Superfluity of Goods Station and Yard Accommodation," "What Goods Traffic Working Really Involves," "Traffic which *is* Suitable for the Gattie Scheme," "Traffic which is *not* Suitable," "The 'Container' System," and "Road Transport." The objections to the scheme from the railway companies' point of view are thus summarised:—(1) It is only suitable for certain sections of goods, those at present dealt with by the usual systems of collecting and delivery vans. (2) It requires not only a complete revolution of railway conditions and methods, but also of trade and industry in all departments. (3) It carries centralisation to a degree which is entirely antagonistic to the general nature of goods traffic other than that covered by (1). (4) It would require, if it is to justify itself, to deal with very large volumes of traffic which need never, and should never, go near the clearing house. (5) It is quite inapplicable to coal and other varieties of traffic, which are themselves main factors in the problems of goods traffic manipulation. (6) It would throw an immense volume of traffic upon the thoroughfares of the central districts which has no business there at all. (7) It would require exceedingly expensive railway connections. (8) It would entail something like a "Traffic Trust," or, if State-owned, would only be practicable under a nationalised railway system, and even then it has not much to commend it; and, last but by no means least, (9) One clearing house is of little value without others in all the large towns, and also on a smaller scale in hundreds of other towns where traffic, while not actually large, is sufficiently extensive to call for equipment, if only so that the scheme shall not be prejudiced where it is in operation. Moreover, it takes no account of the intermediate and roadside traffic which, in the aggregate, is also a very considerable factor. The pamphlet is published at sixpence at 91, Temple-chambers, Temple-avenue, E.C.

THE GERMAN CEMENT INDUSTRY AND THE WAR.

Owing to previous over-production, German cement manufacturers were not in a good position to meet the adverse conditions ensuing from the war, and the effect was felt almost instantaneously. The sale of the South German Cement Syndicate in 1915 only amounted to 22.8 per cent. of the syndicate allotment, against 70 per cent. in times of peace, and for 1916 the sale is 2 per cent. still lower. The position is apparently worse for the Rhenish-Westphalian Cement Union, the sale for 1915 being only 12.86 per cent. of the allotment, a further decline setting in during the present year. The factories endeavoured to counteract the rise in cost of production by higher prices, but the result did not prove satisfactory. Taking the average of 20 leading cement factories, the dividends for 1913 or 1913-14, according to the end of the financial year, amounted to 9.41 per cent., and only two of the factories in question did not pay any dividend. The following year the average dividend had fallen to 4.80 per cent., seven factories being unable to pay any dividend, and for 1915 or 1915-16 the average dividend had fallen to 1.88 per cent., 13 companies out of the 20 works in question being unable to pay any dividend. The table given above shows the capital, the net profits, and the dividends of the 20 concerns in question.

—	Share Capital.	Net Profits or Loss (−).			Dividends.		
		1913 and 1913-14.	1914 and 1914-15.	1915 and 1915-16.	1913 and 1913-14.	1914 and 1914-15.	1915 and 1915-16.
	Marks.	Marks.	Marks.	Marks.	Per Cent	Per Cent.	Per Cent.
Adler Portland Cement Company	5,500,000	725,000	256,000	167,000	6	3	0
Heidelberg-Mannheim Portland Cement Company	1,500,000	2,898,000	1,621,000	312,000	10	6	4
Karlstadt Portland Cement Company ..	3,500,000	507,000	179,000	115,000	8	4	4
Lorraine Portland Cement Company	5,000,000	616,000	119,000	−134,000	9	0	0
Alsen Portland Cement Company, Hamburg	9,000,000	1,844,000	1,042,000	−198,000	21	13	4
Wicking Portland Cement Company	4,500,000	27,000	50,000	113,000	0	0	0
Hanover Portland Cement Company	5,400,000	812,000	358,000	−226,000	9	4	0
Saxe-Thuringia Portland Cement Company ..	3,300,000	547,000	232,000	− 94,000	16	5	0
Breitenburger Portland Cement Company ..	3,500,000	7,000	− 69,000	− 70,000	0	0	0
Saxe-Bohemian Portland Cement Company ..	3,500,000	371,000	164,000	100,000	8	4	2
Mark Portland Cement Company	2,750,000	248,000	− 21,000	−130,000	4	0	0
Silesia Portland Cement Company	2,500,000	362,000	445,000	25,000	13	8	6
Union Portland Cement Company	2,530,000	239,000	80,000	—	7	3	0
Teutonic Portland Cement Company	2,200,000	217,000	376,000	—	8¼	10	0
Saxonia Portland Cement Company	2,000,000	234,000	59,000	37,000	8	4	3
Langerich Portland Cement Company	1,500,000	177,000	5,000	−124,000	7	0	0
Bavarian Portland Cement Company	1,250,000	90,000	88,000	69,000	8	0	0
Giesel Portland Cement Company	1,800,000	247,000	215,000	75,000	11	8	4
Rhenish Portland Cement Company	1,200,000	256,000	− 23,000	− 32,000	12	0	0
Aleucania Portland Cement Company	1,200,000	90,000	110,000	− 41,000	5	4	0

The above list, which comprises typical concerns from the different districts, only embraces a small portion of the works, there being in the different districts works as follow:—

The South German Cement Syndicate comprises 21 kartelised works.

In North Germany there are the Hanoverian Cement Selling Centre, with 10 works; the Union of Nether-Elbe Portland Cement Works, in Hamburg, with six works; the Central German Cement Selling Centre, in Halle, with 15 works; the Berlin Cement Centre, with three works; the Stettin group, with four works; the Silesian Cement Selling Centre, with 12 works; or, altogether, 50 works.

In the Rhineland-Westphalia district there are the Rhenish-Westphalian Cement Union, with 43 works, and the selling centre of the Rhenish-Westphalian blast-furnaces in Düsseldorf, with 5 works; or, altogether, 48 works. Repeated endeavours have been made to bring about an all-German combine of the cement industry, but the efforts so far have been futile. As a way out of the difficulty, attempts have also been made to form separate unions of the three large districts enumerated above, but the task is very difficult on account of the many conflicting interests. In the meantime the Government has enforced several restrictions in connection with production and forward sales which were to remain in force till December 1, 1916. The Rhenish-Westphalian Cement Union has asked the Government to allow these restrictions to remain in force during the continuance of the war and until normal conditions again prevail, and no doubt some sort of a settlement may soon be looked for.

American Locomotive Building.—Orders for 30 engines have been placed with the Baldwin Locomotive Works; of these 20 Pacific and 5 switching locomotives are for the Atlantic Coast line. The number of locomotives ordered in October was no less than 779; this was the largest total reached in any month this year. The orders received for locomotives in the first four months of the second half of 1916 comprised 1,271 locomotives; this compared with 2,124 engines ordered in the first six months of the year. In 1915 the number of locomotives ordered was 1,972.

Submarine Telegraph Enterprise.—After providing for interest, income tax, excess profits duty and all other charges, and bringing into account a reliquat of 85,880*l.* carried forward from 1914–15, the Western Telegraph Company (Limited), had a balance of 534,689*l.* available for dividend for 1915–16. Of this balance the directors allocated 100,000*l.* to the general reserve, 30,000*l.* to the land and buildings depreciation fund, and 100,000*l.* to the provision made for investment fluctuations. Out of the final balance the directors recommend a dividend of 8 per cent. for the past year upon the ordinary shares, carrying forward 38,345*l.* The company's receipts for 1915–16 from the transmission of cablegrams and dividends on investments in other telegraph companies amounted to 888,846*l.* The expenses of the electrical, the engineer's, the captain superintendent's, and the surveyor's departments for 1915–16 were 3,610*l.*, and 67*l.* was paid for the use of patents. War payments to the staff absorbed 12,797*l.*, and maintenance of cables for the 12 months cost 87,651*l.* The cost of the cable used for maintenance purposes in 1915–16 was 25,851*l.*, 8,810*l.* was charged for depreciation of cable in stock, and 1,258*l.* for insurance of cable in stock. The company's maintenance steamers involved the following charges in 1915–16:—Norseman, 29,991*l.*; Cormorant, 13,172*l.*; Norna, 1,239*l.*; and chartered steamers, 7,890*l.* The paid-up share and debenture capital of the company stood at the close of June, 1916, at 2,897,975*l.* The reserves had attained at the same date the following importance:—General fund, 1,940,054*l.*; maintenance ships' fund, 59,160*l.*; marine insurance fund, 75,000*l.*; land and buildings depreciation fund, 245,000*l.*; and guarantee fund, 1,209*l.*; making an aggregate of 2,320,423*l.*, to which should be added 214,685*l.* for traffic and other credit balances. At the close of June, 1916, the company had expended 2,918,695*l.* on capital account, against which it could set 2,157,937*l.* for reserves, and 89,922*l.* for the value of the spare cable on hand.

Scratching for Tin in Queensland.—Amongst the inhabitants of North Queensland there is a not inconsiderable section who are inclined to work lines of their own in the bush, in country districts. One of these occupations is scratching for tin in the river courses and gutters. The object of these seekers is to collect "wash-dirt," that is tin-bearing gravel and coarse sand deposited by the water rushing down these gullies after a drought. No spot, however apparently inaccessible, is left untouched, if there is likelihood of "dirt." In rainy times—which mean business—the tin-scratching industry in the hills along the watershed of Northern Queensland is in full swing, and with plenteous water for washing the scratchers use the "cradle" as their principal agent in recovering the tin which has been torn away from the hill sides by the heavy rain. A resourceful scratcher constructs his cradle out of a hollow log, which he splits in two, so that a trough of some 6 to 8 ft. long results; one end is closed by nailing a board or piece of metal across it. To this end a perforated sheet of iron is fixed horizontally, about 4 in. from the "lips" of the trough. This forms the catchment for the wash-dirt, and bottoms are fixed along the trough, dividing it into sections 20 in. long; these are called "ripples," and arrest the tin falling through the perforated sheet. The completed cradle is tilted lengthways, to allow the water to run away. The scratcher places wash-dirt with a shovel on the perforated sheet, or "box," as it is called, the cradle is then gently rocked and water constantly applied by a fountain with a long handle to it. With one hand the scratcher rocks the cradle, with the other he pours water into the cradle for hours at a stretch, all this, of course, so as to agitate the wash-dirt and separate the tin from the dirt. At intervals the dirt is thrown away, and the tin collected in lumps and bagged. A more ambitious way of collecting tin is by means of "sluice-boxes," that is, primitive troughs with sheets of iron nailed to the bottom. These boxes are placed in such a position in the course of a mountain gully as to receive the flow of water from artificial dams. As the water flows over the iron sheets, men standing by continuously shovel wash-dirt on to the upper end of the box, so that the tin may be deposited and the water escape. In dry times, when no water is available, recourse is had to the "dry blower" process. Bellows work over the wash-dirt, driving the light dirt from the tin. The "dirt" is placed on graduated screens, the larger mesh ones above the smaller. The dirt falls from screen to screen, the bellows being continuously employed. The tin stays on the screens, the useless dirt being blown away.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The closing month of the year is invariably one in which steelmakers endeavour to clear out as much of the work on hand as possible, and this present month is proving no exception to the rule, the predominant feature at the moment being to speed up the output. Consequently the rush of business is tremendous, a strenuous attempt being made to overtake the accumulated arrears which have gathered in every steelmaking establishment in the West of Scotland. There is no abatement in the demand for material of one kind or another required by Government for war purposes, indeed, rather is there an increase than otherwise. Then, too, Government regulations are being very rigidly enforced, so strict a control being maintained over all outputs that the negotiation of ordinary mercantile business is hedged around with difficulties. As permission must now be obtained before certain material required for export may even be manufactured, prices are merely nominal, although, otherwise, the tendency is towards a higher level all round. Whatever mercantile business is being put through runs the risk of being set aside at any moment on account of the great push for Government orders, steel for shell bars still being in exceptional demand. The price for this quality may be put at about 17*l.* per ton, while ship plates are quoted 14*l.* 10*s.* or 14*l.* 15*s.*; boiler plates, 15*l.* 12*s.* 6*d.*, and even over this figure; and angles, 14*l.* 7*s.* 6*d.* to 14*l.* 10*s.*, or perchance 14*l.* 15*s.*

Malleable Iron Trade.—In the malleable iron trade business continues to run on the most satisfactory lines, alike in the iron and steel departments, conditions otherwise remaining unchanged, Government being the chief consumer of the production. A decided firming-up has taken place with regard to the export trade, the inquiries coming to hand giving promise of good business. Little progress can meantime be made in connection with deliveries. The price for "Crown" bars keeps steady, and is quoted 14*l.* 10*s.* to 14*l.* 15*s.* per ton, according to brand.

Scotch Pig-Iron Trade.—Brisk business characterises the Scotch pig-iron trade, and inquiries, both for home and export, are more numerous than makers can well cope with. Hematite is in strong demand, the local steel works being able to consume the whole of the output. In this respect Government control has greatly facilitated matters, the desire being that no establishment occupied on war work should be hampered in any measure in its operations. The continued scarcity of hematite and No. 1 foundry iron has led to a determined effort being made to add to the output by turning as many furnaces as possible on to the making of hematite.

Munition Workers' New Year Holidays.—Owing to the extreme pressure of work, the annual holiday in the engineering and allied trades will be much curtailed, and a notice has just been issued that work will cease at midday on Saturday, December 30, 1916, and be resumed on the morning of Thursday, January 4, 1917.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The attention of all interested parties is being directed more and more to the question of transport. Supplies are accumulating here owing to the want of rolling stock to convey them to the different consignees. The falling-off in deliveries has had a pronounced effect upon the open market, for colliery companies are chiefly concerned with fulfilling their obligations under the contracts with the munition works, blast-furnaces, and railways. Outside these channels there is not much fuel available, and all branches of manufacturing fuel are strongly held. Steam coal inquiries are heavy for export purposes, but only allied countries appear to get full requirements. Steam nuts are a slightly better delivery, but cobbles and slacks are tighter. The house coal position is extremely active. Gas companies are taking ample supplies of the inferior sorts. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slack, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton.

Iron and Steel.—The general position contains many interesting features, but all are affected by the irregular transport service. This was accentuated by the fogs during last week. Notwithstanding many difficulties and countless regulations the local output continues on progressive lines, and the production of finished and semi-finished goods now aggregates a very substantial figure. All classes of material meet an improving demand. Special hematites are still far and away the most eagerly sought, and supplies are good. Basic iron is now being offered on a larger scale. Forge and foundry irons remain very active. Steel billets are being extensively purchased whenever possible, and top prices rule in every case. The heavy foundries and engineering shops generally have an abundance of orders, but depression again prevails in the case of the light foundries owing to stagnation in the building trade. Stove grates, rain water manufactures, &c., are hardly wanted at all. The abolition of Sunday work has given great satisfaction here, where it is believed a six days working week will produce an equal, if not a greater, amount of output. From overseas we have to announce indents for files, saws, wire ropes, spades, machinery and parts, steel plates, steel, hardware and cutlery.

Development of Sheffield.—The Sheffield City Council to-day appointed a special development committee. It will exercise special watchfulness over the city industries, and consider what inducements should be offered to attract new undertakings. Col. Hughes remarked that the extension and addition of munition works had swallowed up all available sites, and as much as 5,000*l.* per acre had been offered for sites with suitable railway and other facilities. These had not been at liberty.

Sheffield Trade Matters.—The Order in Council of December 8 is likely seriously to affect the non-ferrous metal trades of the city. By this it is prohibited to use copper for other than munition purposes, thereby cutting off the essential supplies to cutlers, silversmiths, brass workers, electro-plate makers, &c. When the present stocks of copper are exhausted they cannot be replaced, with the result that the output of Sheffield goods, other than munitions, particularly those made of "German silver," or what we now call "nickel silver," will be seriously reduced. This material, for which copper is an indispensable and the main component, is used to make spoons, forks, teapots and all kinds of hollow ware, nickel knife handles, knife scales, and the like, and it is largely provided for the Sheffield trades by the Birmingham metal suppliers. It will now cease to be produced with copper prohibited. There are no substitutes available, for such other metals as aluminium or the like, which were once used, have been for some time restricted for Government work only. The outlook of the particular Sheffield trades concerned is very grave. We were to-day informed by leading manufacturers that their works will automatically close down when the copper stocks become exhausted. In this way a huge export trade will be lost to the city and hundreds of people thrown out of employment. It is felt that the Government cannot fully appreciate the gravity of the prohibition, and steps are to be taken to acquaint them with it.

A GERMAN-AUSTRIAN SLEEPING CAR COMPANY.—Under the style of "Mitropa," the Central European Sleeping and Restaurant Car Company, a new concern, is being formed with a capital of 5,000,000 marks, likely to be increased by degrees to 40,000,000 marks. Hitherto the Franco-Belgian International Sleeping Car Company has held a monopoly also in Germany and Austria; in the former country the company directed several international *trains de luxe*, and it also controlled the German Dining Car Company by virtue of owning the majority of the shares. The Austro-Hungarian and the German State railways departments have now decided to form the above company, which will obtain the monopolies formerly held by the former concern, as the contracts can be made to expire.

WORK-THERAPY FOR DISABLED SOLDIERS.—Some success has been obtained in Germany with experiments in hastening the restoration of injured and mutilated soldiers by giving them suitable occupation in works as soon as the medical advisers consider them fit. The treatment, known as work-therapy, begins, if possible, while the patient is still receiving medical attention. The idea is not only that medical treatment and artificial limbs are not sufficient to fit a man for work again, but that the bodily exercise and useful occupation is a beneficial factor in the recovery. A beginning was made by Dr. H. Beckmann in the Accumulatorenfabrik A.G., of Oberschöneweide, near Berlin, where patients were given light work in the joinery department. The men were learning to use their limbs, natural or artificial, again, they gained confidence, and were usefully occupied. Rules have been drawn up in electrical works to regulate this work, which is under the supervision of a doctor and the engineer. A minimum rate of pay has been fixed; so far as possible disabled men are to be placed between able-bodied workers in the works.

AGRICULTURE IN BRAZIL.—The following notes on opportunities for trade in farm equipment in Brazil are taken from a recent address delivered by the Chief of the United States Bureau of Foreign and Domestic Commerce, reports of which have appeared in the American press. Brazil's crop of coffee amounted in the past year to 2,508,000,000 lb. There were probably not less than 4,500,000 acres devoted to the raising of coffee. This land, after it has been cleared, is ploughed by means of 6 to 12-in. walking ploughs or with reversible disc ploughs having 24-in. discs. Wherever it is possible to do so, the land is then harrowed with disc harrows, followed by harrowing with spike-toothed harrows. The young plants are planted out, or the seed is sown, some growers using one method and some the other. During the rainy summer months the weeds grow fast, and it is necessary to work the land between the plants with five-tooth cultivators, pulverising harrows, or even with hand hoes. The Brazilian coffee grower often takes two 30-tooth sections, and, placing them side by side, secures them with four strips of hardwood. These strips are quite heavy and are bolted to the harrow sections; in this way, a solid 60-tooth harrow is made, which, on account of the weight of the wood, penetrates the soil, thoroughly working it and destroying the growth of weeds. There is, therefore, a market for walking ploughs, reversible disc ploughs, disc and spike-toothed harrows and pulverising harrows in Brazil. Often the growers plant maize between the rows of coffee trees, and for that purpose use one-horse corn planters, with either double-disc or runner-furrow openers and with pressure wheels.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is a moderate business passing in Cleveland pig-iron. All legitimate home needs are being met and fair quantities of iron are available for shipment. Local consumers are taking more and more supplies of forge iron to mix with the superior qualities, and as most makers have rather considerable stocks of forge the steadily growing inclination to use more of that description is very gratifying. Some producers are disposed to rather shade the maximum price of forge which has ruled for some time past. For home consumption, No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge are all quoted 87*s.* 6*d.*, and No. 1 is put at 91*s.*; for shipment to our Allies No. 1 is 102*s.* 6*d.*; No. 3, 98*s.*; No. 4 foundry, 96*s.* 6*d.*; and No. 4 forge, 95*s.* 6*d.*; and for export to neutral countries the minimum rates named are 105*s.* for No. 3 and 110*s.* for No. 1. With the exception of permits to send very small lots to Scandinavia under very exceptional circumstances, however, licences for export to neutrals are unobtainable.

Hematite Iron.—A steady, firm feeling prevails in the East Coast hematite branch. Further negotiations for deliveries over periods next year are stated to have resulted in more contracts being arranged. Most manufacturers are quite prepared favourably to consider offers on forward account, but prompt business is all but impracticable. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Stock and Shipments of Pig-Iron.—For the first time since July 26 last an addition of Cleveland pig-iron to the public warrant stores has to be recorded this week, 50 tons of No. 3 having been sent into the stores. The addition is said to be due to the cancellation of a sale of pig-iron. The stock of Cleveland pig in the warrant stores now stands at 4,123 tons, consisting of 4,087 tons of No. 3 quality and 36 tons of other kinds of iron deliverable as standard. Shipments of pig-iron from the port of Middlesbrough quite fulfil expectation. So far this month they amount to 13,010 tons, as compared with 9,780 tons to the same date last month, and 19,245 tons for the corresponding part of December last year.

Coke.—Qualities of coke needed for local use continue in very good request, and values of such descriptions are fully maintained, notwithstanding the more than ample supply. Average blast-furnace kinds keep at 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is still quoted for qualities low in phosphorus.

Foreign Ore.—Imports of foreign ore to the Tees are on a satisfactory scale.

Manufactured Iron and Steel.—Very little news of moment is ascertainable concerning the various branches of the finished iron and steel industries. Manufactures are kept fully employed, very largely on Government work, but the output of material for mercantile shipbuilding is also considerable and is steadily increasing. Quotations, all round, are strong. To home customers common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; heavy steel rails, 10*l.* 17*s.* 6*d.*; packing iron and steel (parallel), 12*l.*; and packing iron and steel (tapered), 14*l.* 5*s.* The following prices are named for export:—Common iron bars, 15*l.*; steel ship plates, 13*l.* 10*s.* to 18*l.*, according to diameter; steel sheets (singles), 20*l.*; steel sheets (doubles), 22*l.*; and heavy steel rails, 11*l.* 5*s.*

RUSSIAN METALLURGY.—The production of pig-iron in Russia last year was 4,062,100 tons, as compared with 4,769,300 tons in 1914. The output of semi-finished steel was 4,539,100 tons, as compared with 5,508,800 tons; and that of finished steel, 3,599,500, as compared with 4,334,100 tons. Of the semi-finished and finished steel 60 per cent. was produced in Central Asia, while the Ural region made 20 per cent. Of the pig-iron made in Russia last year rather more than 70 per cent. was produced in Central Russia.

THE MAURITIUS.—Machinery for local industries was imported into the Mauritius in 1914 to the value of 48,711*l.*; practically all the machinery imported came from the United Kingdom. Some of the rolling-stock for light tramways is of foreign manufacture. There are 405 miles of telegraph and 109 miles of telephone under the charge of the colonial postal and telegraphic department. The Mauritius has a single-line railway about 120 miles in length, exclusive of the Bois Cheri light railway; the gauge is 4 ft. 8½ in. The rebuilding of timber bridges in ferro-concrete was continued by the colonial public works department in 1915. Sites for reservoirs at La Ferme and La Nicolière have been acquired in connection with irrigation. A dam for the La Ferme reservoir is in course of construction, and the reservoir will be completed to its full capacity of 417,000,000 cub. ft. Drainage works were commenced at Port Louis in 1895, sewers being designed on the separate system. The sewerage is pumped through cast-iron pipes for 7,000 ft. to the sea outfall at the mouth of Grand River, North West, and is discharged in 10 ft. of water at low tide, 1,000 ft. from the shore. The total length of the sewers laid is 25¼ miles.

THE WORKS OF MESSRS. E. G. WRIGLEY AND COMPANY, LIMITED, BIRMINGHAM.

(*For Description, see Page 575.*)

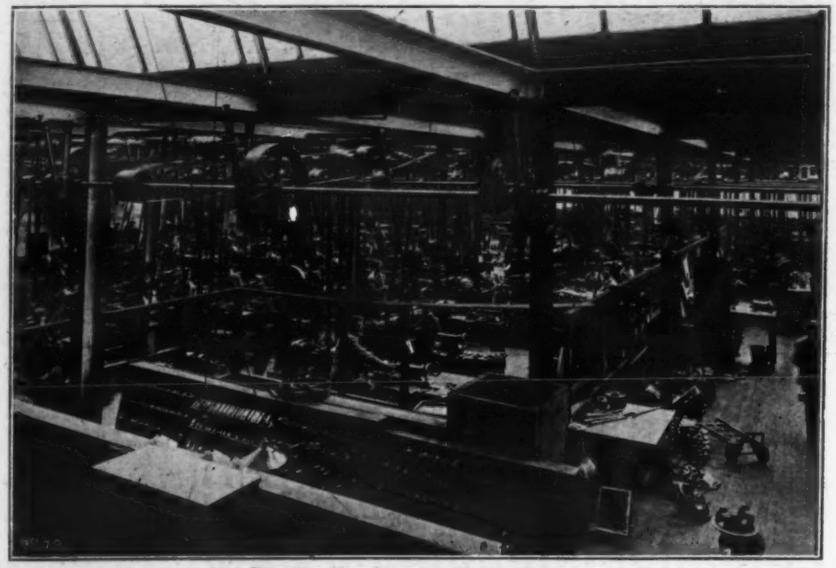


Fig. 60. The Turning Department.

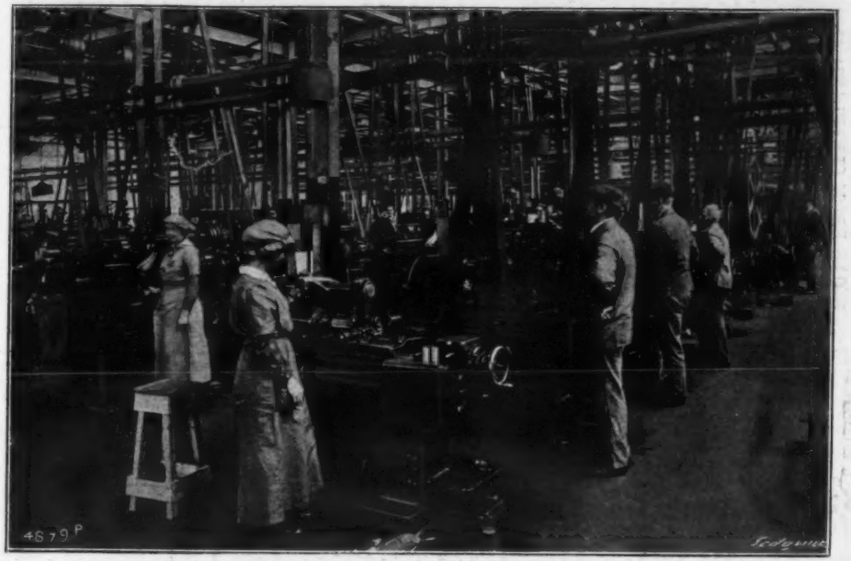


Fig. 61. The Gear-Cutting Department.

Fig. 62. The Small Tool Department—View Room.

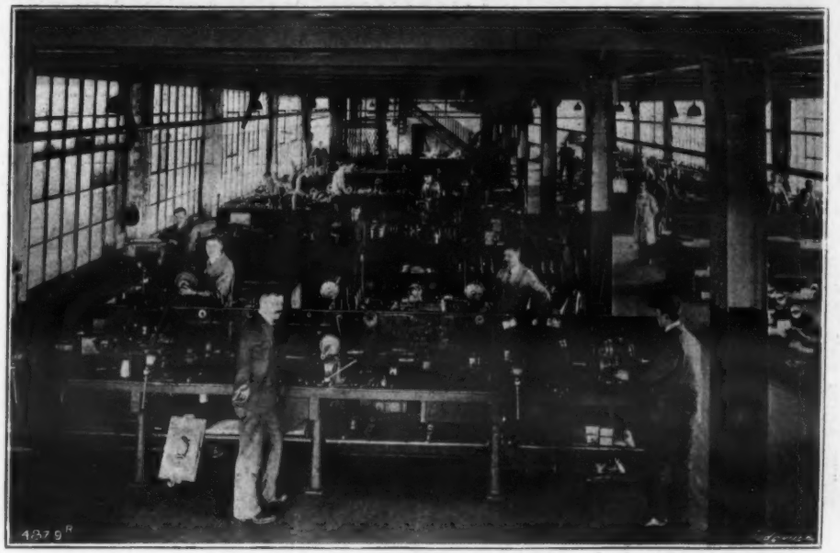


Fig. 63. The Fitting Shop.

GEARED TURBINE INSTALLATION FOR SINGLE-SCREW CARGO SHIP, THE ELLERMAN LINER "CITY OF CANTON."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 581.)

Fig. 1.

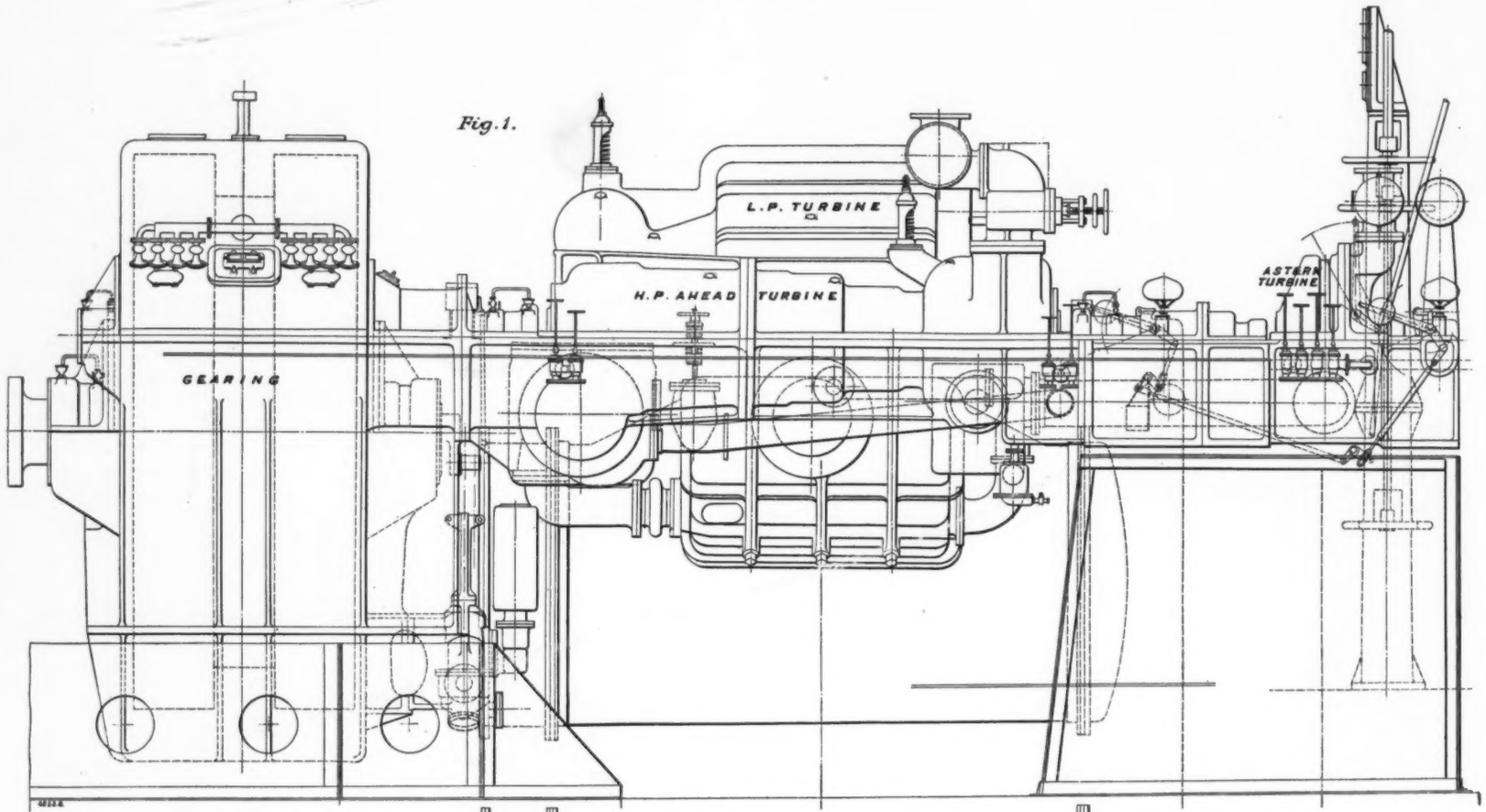
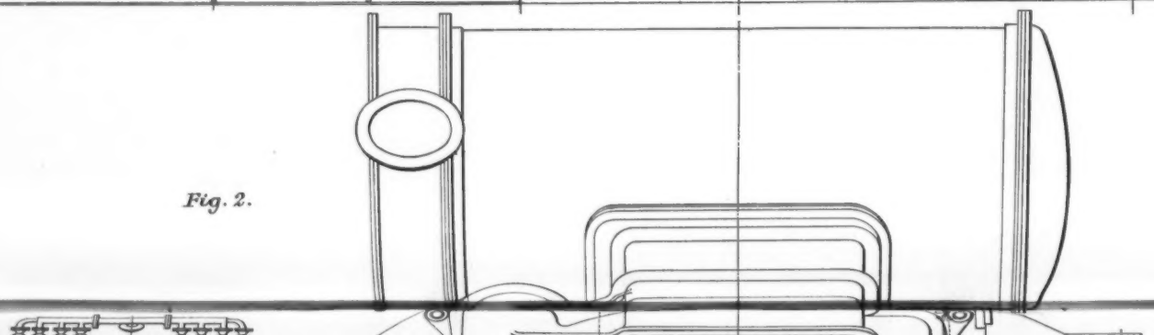


Fig. 2.



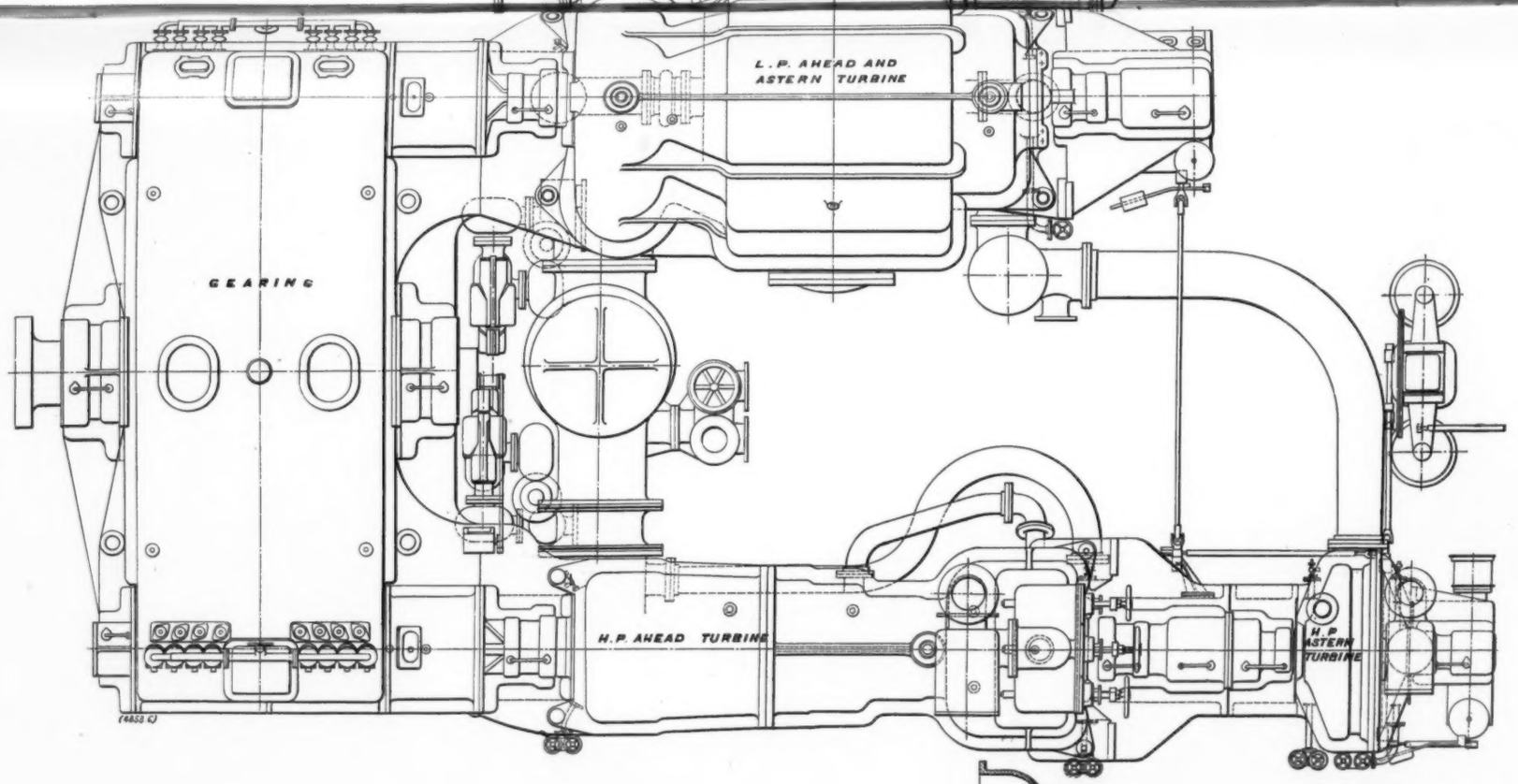


Fig. 3. HALF SECTION THROUGH H.P. AHEAD TURBINE AND PINION SHAFT.

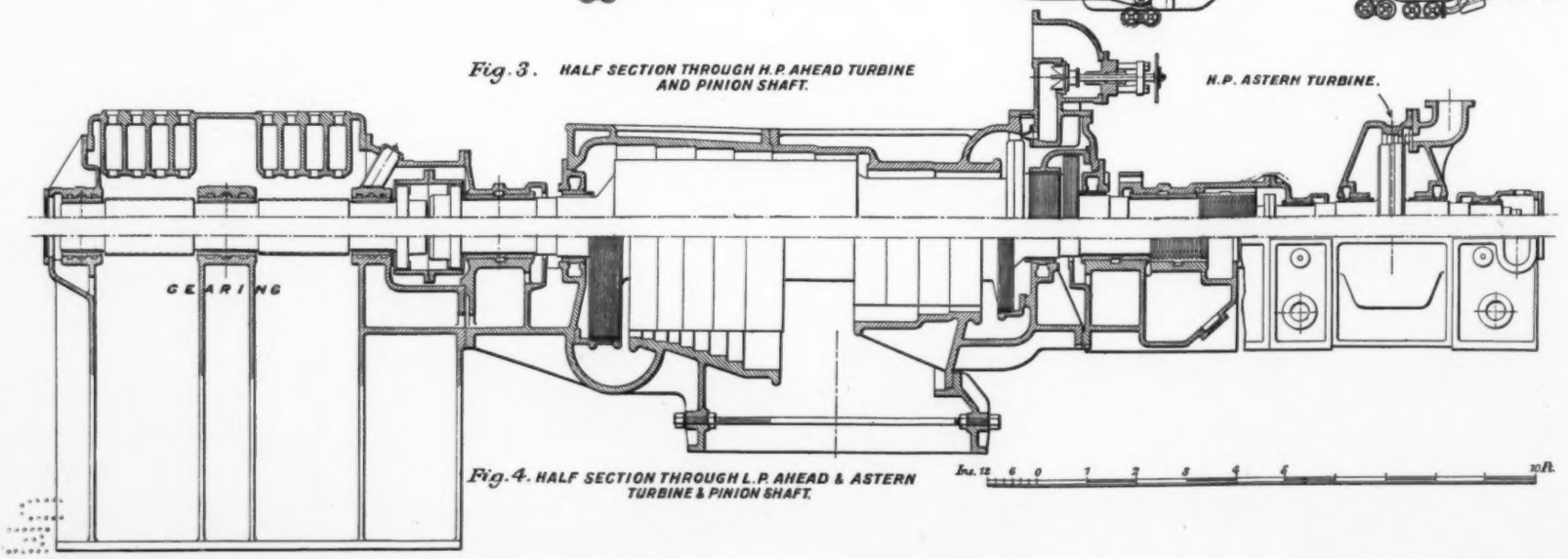


Fig. 4. HALF SECTION THROUGH L.P. AHEAD & ASTERN TURBINE & PINION SHAFT.

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"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom £1 15 6

The increase in the annual subscription is entirely due to the new postage rates on newspapers.

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Thin paper copies £1 11 6 (£7.65)
Thick ,, ... £1 16 9 (£8.75)

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Thin paper copies £1 16 0
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Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 15, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. Paper: "Variable Speed Gears for Motor Road Vehicles," by Mr. Robert B. Phillips, Member.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 15, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate Road, Newcastle-on-Tyne. The discussion on the following paper will be resumed:—"Works Organisation," comprising "Manufacturing Organisation," by Mr. A. D. C. Parsons, B.A., Member, "Financial Organisation," by Mr. Edwin L. Orde, Vice-President, "Selling Organisation," by Mr. G. H. Tweddell, Member.

THE ASSOCIATION OF MINING ELECTRICAL ENGINEERS: MIDLAND BRANCH.—Saturday, December 16, at 3.30 p.m., at the Midland Hotel, Mansfield. Paper for discussion:—"The Report on Electric Signalling with Bare Wires, by Mr. R. V. Wheeler, D.Sc., and Professor W. M. Thornton, D.Sc., D.Eng., and means of overcoming difficulties in connection with same."

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, December 16, at 7.15 p.m., at the Institute, Wolverhampton Street, Dudley. A paper will be read on "Further Notes on the Growth of Cast Iron after Repeated Heatings," by Professor H. C. H. Carpenter, M.A., Ph.D., of the Imperial College of Science and Technology, London.

THE FARADAY SOCIETY.—Monday, December 18, at 8 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. (near Waterloo Bridge). The following papers will be read:—"On a Precision Method of Uniting Optical Glass—the Union of Glass in Optical Contact by Heat Treatment," by Mr. R. G. Parker, B.Sc., A.C.G.I., and Mr. A. J. Dalladay. "The Effect of Pressure on the Equilibrium Constant of a Reaction in a Dilute Solution: a Simple Proof of the Expression," by Mr. W. C. McCullagh Lewis, M.A., D.Sc. The following papers will be communicated by the President:—"Do Equiatomic Solutions in Iron Possess Equal Resistances?" by Mr. E. D. Campbell. "Grain Growth in Deformed and Annealed Low Carbon Steel," by Mr. Ralph H. Sherry, M.A. Mr. Ezer Griffiths, M.Sc., and Mr. E. A. Griffiths will describe and exhibit a new electric furnace for testing the softening points and compressive strengths of refractory materials.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, December 19, at 8 p.m., at the Royal Society of Arts, John Street, Adelphi, W.C. The following paper will be read:—"Notes on the Subject of Geological Mapping," by Mr. S. Lister James, F.G.S. The chair will be taken by the President, Professor John Cadman, C.M.G., D.Sc., M.Inst.C.E.

EAST INDIA ASSOCIATION.—Monday, December 18, at 4.15 p.m., at the Caxton Hall, Westminster. A paper will be read by Sir Guilford L. Molesworth, K.C.I.E., on "Indian Weights, Measures, and Money." Lieut.-Colonel Sir Albert K. Rollit, D.C.L., LL.D., will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 19, at 5.30 p.m. Paper to be further discussed:—"Experiments on Earth Pressures," by Mr. Ponsonby Moore Crosthwaite, B.A.I., M.Inst.C.E.

THE ROYAL SOCIETY OF ARTS.—Wednesday, December 20, at 4 p.m. A paper on "Classical and Scientific Education" will be read by Mr. Arthur C. Benson, C.V.O., Master of Magdalene College, Cambridge. The Right Hon. Viscount Bryce, O.M., D.C.L., LL.D., F.R.S. will preside.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, December 21, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, London, W. The following paper will be submitted for discussion:—"The Economic Geology of the Insizwa Range," by Mr. W. H. Goodchild, Member.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, DECEMBER 15, 1916.

EFFICIENCY IN NATIONAL ORGANISATION.

WE have never in this journal been concerned with party politics. Governments may come and Governments may go, so far as we are concerned. Conditions to-day, however, are highly abnormal. The new Government, which has this week come into office, differs materially from all others in the history of the nation, not alone because of the special circumstances under which it has come into being, but because of the determined attempt made to differentiate between party obligation and individual efficiency in appointments to the several offices of State. We have on normal occasions contended for the choice of business men to control business departments of the Government, and while we welcome the decision of the First Minister of the Crown on this occasion, we are not disposed, as in the case of others, to regard the change as a permanent revolution in ministerial appointments. Enough for the day is the satisfaction, as well as the evil thereof, and as the appointments thus made are almost exclusively concerned directly with the speeding up of those industries on which the fighting army is dependent, we feel justified in expressing a high degree of satisfaction. We hope that there will be less of rhetoric and more of vigorous action in the carrying on of the Government. It took seven days of trumpeting to bring down the walls of Jericho; to-day a battery of guns would bring them down in seven minutes. If the defence of our enemies is to be broken down, it will not be by trumpeting, vocal or instrumental, but by an adequate supply of guns and shells, and of the men to utilise them.

Apart from the admirable selection for the War Cabinet of five men endowed with large experience, extraordinary virility and high reputation, meriting public confidence, we have at the head of the business departments men whose training and qualifications command support among the rank and file of British workers. For the first time in history the trade, agricultural and educational departments are headed by men chosen because of their intimate knowledge of the work for which those departments are responsible—respectively Sir Albert Stanley, Mr. R. E. Prothero and Dr. Fisher of Sheffield University. The President of the Local Government Board, Lord Rhondda, is one who by training in industry has acquired the faculty of organisation to a high degree. We have a special Minister of Labour in the person of Mr. John Hodge, and a special Minister of Pensions in the person of Mr. George Barnes, both of them trade unionists capable of broad sympathies, and with such intimate knowledge of labour conditions as will enormously assist the new Government in supporting Mr. Henderson, who occupies a seat, without portfolio, in the War Cabinet. In the case of each of these offices we may anticipate more forceful action, specially directed, with experience, towards the attainment of efficiency in the man-power of the nation. But it is vitally essential that initiation and change resulting from the appointment of business heads of departments with new ideas and new aims shall not be thwarted by the mandarins of the permanent staff, who have had too much influence in the past. We have time and again contended that our man-power is adequate for all the work, strenuous beyond compare, demanded under the present stress of war; what is necessary is organisation to achieve the fullest efficiency. This requires, first, the absorption in the national service of everyone physically fit, and, second, the utilisation of the physical effort of each individual in those functions where his personal ability can most effectively be employed. Most thorough organisation is necessary to secure these ends, but until they are achieved we have no right to expect victory. It is because of this that we welcome the appointment of three of the best of the trade union leaders to high posts in the Government, and of four or five to under-secretaryships. These men, endowed as they are with a patriotism as great as is their experience of the personal idiosyncrasies of the British working man, can, and we are sure will, assist towards the aims indicated, not only in organisation but by the exertion of personal influence. The time has come, is indeed long overdue, when individual predilections and privileges must be made subservient to the national aim. In this we would even include the women of the nation, because the work that so many have done with loyalty and unselfish courage shows that the so-called weaker sex is capable in emergency of service which demands endurance, continuous physical effort and as much intelligence as each may possess.

Industry, however organised to ensure the highest efficiency, is in itself futile unless there is provided the raw material with which to feed the worker, and to feed the furnace and the machine tool. Unfortunately, as a nation we failed in that prescience which would have rendered us less dependent upon foreign supplies, alike of food and of the raw ironstone and other minerals requisite for the manufacture not only of peace products but of possible war material. Even after war had been thrust upon us there was failure to recognise the fundamental requirements even of those industries without whose productions the heroism of our troops could be of little avail. We are not, however, going to enter upon a criticism of incapacity and laxity in the past. The burden of responsibility will, we hope, be placed on the right shoulders at the right time. What is wanted now, if we are next year to exhibit in the fighting line the full strength of all our man-power, is a recognition of the need

for drastic and systematised methods. The scientist has put the factor of efficiency in the forefront of his work, and has established clearly-defined measurements of this necessary condition. But in the affairs of life there has not been the same determination to establish standards wherewith to test how nearly our efforts have attained the fullest achievement individual or otherwise. We are therefore, glad that there has been appointed a food controller in the person of Lord Devonport and a shipping controller in the person of Sir Joseph Maclay. The former is an expert in food supply; the latter belongs to a private firm of owners of just that type of ship which is most urgently needed to supply our wants. Mr. Prothero, at the Board of Agriculture, and Lord Devonport, at the Food Control Department, can do much to achieve efficiency, first, of the soil of the United Kingdom, and, second, in the distribution and consumption of food supplies.

In respect of the first-named necessity it cannot be too often urged that enough has not been done in this country in the encouragement of agriculture. We cannot expect to reap where we have not sown, and it should be the duty of the new war Government at once to tackle that problem and to increase the acreage of food-supplying soil, and to intensify by fertilisers every acre of land now yielding food. The limitation of acreage under crops cannot be explained away by the absence of labour; it is rather due to the inefficient use of the labour available. All of military age must answer the call to arms, but as some considerable part of their requisite training takes the form of physical exercise, work on the farms could be of dual advantage. Moreover, there is no adequate reason why our prisoners of war and interned aliens should not be put to work; or, again, why black labour should not be imported, in order that every available acre should yield its full value in foodstuffs. This applies in equal measure to timber supply and to the afforestation of the country. In the great moorlands it would be as easy to erect barbed war fences to contain our prisoners of war as around such comfortable quarters as the Alexandra Palace. The same conditions apply with equal force to the completion of great dock works, in anticipation of increased post-war trade, such as those being carried out by the Port of London Authority, and others. Such dock works have to be fenced in in any case, and the addition of barbed wire and temporary lodgment could easily be arranged for. At the same time the guarding of alien enemies might even be simplified. We are satisfied, too, that such work would be morally, physically and perhaps spiritually better for the prisoners than enforced idleness. As regards increased output of foodstuffs, it is a remarkable commentary, as instanced by Professor Somerville of Oxford, that we are exporting 250,000 tons of sulphate of ammonia, whereas its use on the land would increase the production of wheat by 550,000 tons, so that in transhipment—in the export of fertiliser and the import of foodstuffs—there would be a saving of 800,000 tons. Financially there would be great gain, because the fertiliser exported, taken at an average price of 16*l.* 14*s.* per ton, brings us only 4,175,000*l.*, whereas the wheat imported costs us, at 3*l.* 10*s.* per quarter, 8,750,000*l.*—leaving a credit balance, apart altogether from our saving in oversea transport, of over 4,500,000*l.* Here is a case where the agricultural and food controllers may be able to influence, in great degree, the shortage of our material and food supplies by increasing output and economising in the use of shipping.

The work of the Ship Controller is also of vital importance to the prosecution of the war. The loss of shipping by submarine attack is regrettable, but so far cannot be said to have achieved the aim of our enemies. The shortage in tonnage, which undoubtedly affects the situation, is due rather to the enormous demands made for ship tonnage to convey our troops and their war equipment, and for other purely military purposes. We are suffering, too, from the grave disadvantage consequent upon the almost entire cessation of merchant shipbuilding for two years, due to the absence of labour and to the absorption of steel for the production of war munitions of all kinds. Hitherto little has been done to rectify the situation. In a previous article (page 485 *ante*) we have pointed out how women's labour may be utilised in merchant shipbuilding to an extent which is only possible of achievement with the fullest patriotic support of labour and with a high degree of unselfishness on the part of the women of the country. This is not a time for allowing social conventions to interfere with the vigorous prosecution of the war. Our manpower, including the work of women, capable physically and intellectually, must be utilised to an extent and in processes far beyond the conception of bygone times. Sir Joseph Maclay's duty is therefore twofold. He must expedite as far as is humanly possible the building of new ships, and at the same time exert the greatest effort toward the attainment of efficiency in the use of existing vessels. The former work not only requires the enlistment of more women into the ranks of shipyard employees, but the inculcation of our vital need for the last unit of physical energy of every worker every hour and every day. Beyond this, there is need to concentrate attention on the ships which are most suited to our immediate requirements, and particularly in the case of such ships which may be furthest advanced. This requires some measure of co-ordination and the pooling of workers in each district, as is now being done on the Wear, under agreement reproduced in our Industrial Notes, so that there shall be the quickest mobilisation of possible tonnage.

The second function of the Ship Controller must be to utilise to the greatest possible extent the vessels afloat. Every engineer knows that efficiency must be measured by the output of men or machines within a given period of time. Thus every hour of idleness detracts from the efficiency attained. That this applies to shipping has not been fully grasped by those responsible for the utilisation of man-power. Every day that a ship of 7,000 tons deadweight capacity remains in port means the loss, in the case of a 10-knot ship, of 70,000 ton-miles per hour. Every week lost in port means the loss of a ship's cargo of iron ore from Bilbao for our blast-furnaces. It will thus be realised that ship control requires, almost as a fundamental condition, adequate labour at ports to ensure the "turn-about" of a ship in the shortest possible time. If the requirements of the fighting force cannot allow a sufficiency of dock labour to ensure this necessity, then labour must in this case waive its objection to the importation of blacks. Prisoners of war in this country should also be used for the work.

The new Government for the prosecution of the war promises to be more capable of achieving victory, which is an imperative necessity for this country and her allies, if not for the world. But no Government, however capable of organising efficiency, can succeed unless it has the active support of every unit of the nation. We are sure that Mr. Lloyd George's War Government will do their duty. We can only hope that the immense influence which each individual in the Government can exert in his own particular sphere of activity will help also to a fuller realisation of the national need. There is still an immense work to be done in rousing the conscience of a very considerable portion of the public to the necessity of individual sacrifice not only of money, but also of accustomed comforts and pleasures. As we have said, the individual, with all his rights and privileges, must become merged in the nation with all its grave necessities. Unless this is accomplished, rights and privileges as individuals or as a nation may be swamped by the ruthless and inhuman government of the enemy victor. The time has come when each unit of the nation, however humble his position or insufficient his capacity, must do that duty which can best promote the national safety. The war must be prosecuted with unity of purpose, mental virility and physical vigour on the part of each and all. We cannot win reposing under an eiderdown or with kid gloves on our hands.

Nor can we listen to the enemy's official overture for peace negotiations, except his terms agree with ours, which are to make certain, beyond possibility of doubt, that our children and our children's children shall not be wantonly subjected to the horrible experiences of our generation of devilishly conceived barbarities, of scientifically planned cruelties, of "red ruin and the breaking up of laws."

THE SPECIFIC HEAT OF SUPERHEATED STEAM.

We do not know whether it was the physicist or the engineer who was the first to suspect that Regnault's value for the specific heat of superheated steam was, to say the least, inadequate, although it does represent fairly the average value of the specific heat of steam in the actual conditions of his experiment. At any rate engineers were soon led by the discrepancies observed in engine practice, when the steam supply was not only superheated but also at high pressure, to conclude that the specific heat of such steam increased considerably as the pressure rose. Opinions varied greatly, however, as to the amount of this increase, and the necessity for further experiment became obvious. These were instituted in a number of different laboratories, and it would perhaps not be unfair to say somewhat lightheartedly. The difficulties of the experiment were far from being suspected, and indeed it was not till some years later that it was pointed out that even the values for the specific heat of the permanent gases as determined at the Reichsanstalt were vitiated by systematic errors. With steam the difficulties attending the use of a similar method are much greater, and perhaps insuperable when the pressure of the steam is much higher than that of the atmosphere. At one time it was hoped that the elaborate and costly experiments of Knoblauch and Jakob had practically settled the matter, but the values found have proved to be irreconcilable with the observed pressure, volumes and temperatures of the steam, and in the neighbourhood of saturation are particularly erroneous. The difficulties attending their method of experimenting may be gauged by the fact that in still later experiments by Knoblauch and Mollier the corrections which it was necessary to apply were of the same order as the variation in the specific heat sought. It has, in fact, taken nearly twenty years' experiment before it has been possible to determine with precision the specific heat of steam at atmospheric pressures when superheated some 5 deg. C. The importance of an accurate determination of the specific heat in these conditions is very great. The average value of the specific heat of steam at this pressure when highly superheated is fairly well known, and by determining its variation with rise of temperature, the total heat of steam at atmospheric pressure and at any temperature becomes known. With this acquired the total heat of steam at any other temperature and pressure can be found by a relatively simple experiment, in which the steam is expanded through the equivalent of the porous plug used by Thomson and Joule in determining the deviation of air and other gases from the theoretical standard of perfection.

The new determination of the specific heat of steam at atmospheric pressure and near its saturation point has been effected in Professor Callendar's laboratory by Mr. J. H. Brinkworth, A.R.C.S., B.Sc., and was described in a paper read before the Royal Society last year and since published in their "Philosophical Transactions." The result reached was a value of 0.4856 at 104.5 deg. C.

The plan followed was to pass a current of steam over an electrically-heated coil, and to note the rise of temperature and the weight of steam passed. The specific heat could then be deduced from the electric energy expended on the coil, which could be determined with very great accuracy. To ensure precision in the temperature measurements these were taken with platinum thermometers.

The earlier experiments of the series suffered from two defects, viz., a loss of heat by conduction and radiation, which was appreciable in spite of the relatively low temperature of the steam and the care taken to insulate the apparatus. Again, steam in the immediate neighbourhood of saturation is extremely liable to carry over with it small particles of water in suspension. If the water be pure these tend automatically to evaporate, since a drop of pure water can never be in equilibrium with steam at the same temperature. Its surface tension tends, as it were, to assist evaporation by squeezing out the molecules. If, however, the water contains any impurity dissolved in it, the

vapour pressure corresponding to a given temperature is lowered, and hence a drop of such impure water may persist even when its temperature is the same as that of the surrounding steam. To attain the standard of accuracy desired it was necessary that the steam should not contain as priming more than one part in 100,000 of water, and as water has some solvent action on glass the boiler and connecting tubes used in the final series of experiments were made of block tin, whilst the calorimeter itself was enclosed in a vacuum vessel of fused silica. Even then, however, it was found that the results obtained were not absolutely independent of the rate of flow, showing that there was still a perceptible loss by radiation and conduction. The necessary correction was determined by making observations at three different rates of flow, and assuming that the loss could be expressed by two terms, one proportional to the temperature rise and the other inversely proportional to the rate of flow. The three observations at different rates of flow provided the means of eliminating these two terms, which were in any case small.

It was further found that a sufficient distance must be allowed between the heating coil and the thermometer, or the steam would not be thoroughly mixed, thus giving rise to discordant readings. Passing the flow through wire gauze was found to be but an imperfect method of securing an adequate mixture, better results being obtained when the steam was compelled to follow a spiral path in passing from the heating coil to the thermometer.

As already stated, the value finally obtained for the specific heat of steam at atmospheric pressure and at 104.5 C. was 0.4856. One result of this research would appear to be that the direct determination of specific heats at high temperatures and pressures by similar methods is impracticable, as the errors arising from the various causes above mentioned would all be aggravated, and this no doubt accounts for the fact that Knoblauch and Jakob's values of the specific heat of steam which have been relied on by many computers of steam tables, are inconsistent with the better-known values of the corresponding pressures and volumes. Such tables, when used in reducing steam engine and steam turbine tests, give efficiency ratios 1 to 2 per cent. too high. On the other hand, boiler tests suffer, as the evaporative efficiency is higher than the tables would indicate.

SOCIAL AND INDUSTRIAL CONDITIONS AFTER THE WAR.

THE treatment of the question of the social and industrial conditions to be established after the war, by so eminently qualified an authority as Mr. F. W. Lanchester, who discussed this subject in his presidential address before the Junior Institution of Engineers last Monday, is to be welcomed. In previous papers and addresses to our technical societies Mr. Lanchester has manifested the same originality of thought and acuteness of observation and deduction, which, according to a leading authority, made the original Lanchester car in a number of important details some five years ahead of all competitors, and his address as president exhibits the same qualities.

In his version of the story of Prometheus, as related in the "Water Babies," Kingsley maintains that Epimetheus was the wiser of the two brothers, and that by his constant study of the past he at length reached a stage in which he could often make reliable forecasts as to the future, whilst the conclusions reached by the *a priori* methods of his impulsive brother were constantly falsified by events. Epimetheus accordingly became, Kingsley says, the direct ancestor of the engineer and of all others who have contributed to the moral and material progress of the race. In due accord with such ancestry, Mr. Lanchester attempts to deduce what has to come from what has been, and ventures, accordingly, to doubt whether the present will be the final war. About every hundred years, apparently, some individual with more power concentrated into his hands than it is good for a human being to hold starts a world war, in which the advantages of a central position and of unity of control for long offset the greater resources of those banded to resist the imposition. Relatively speaking, Mr. Lanchester holds the present war as in no way more serious than the Napoleonic wars of some hundred years ago. In this latter case it must be admitted that the nations to be brought under subjection were offered in return considerable material advantages in the abolition of feudal privileges if they consented to the emperor's schemes. Joseph Napoleon would have undoubtedly given the common people of Spain a better government, even if an alien one, than they ever enjoyed up till very recent days. So, too, a submission to the Hun would undoubtedly involve material gain to certain classes of the community. Industrial capital would certainly be much more secure, such events as the great railway strike of 1912 or that recently threatened in America being impossible where the Prussian drill serjeant holds sway. As in the case of Spain, however, the very classes which would benefit most by the alien success have been those most strenuous in maintaining the necessity of resistance to the end. As in the Napoleonic wars, there is in this country a small minority anxious for peace at any price, but whilst it was the upper classes in Spain who furnished the bulk of these recreants, the majority of them in the present catastrophe belong to the proletariat, who have all to lose. The one recruit of intellectual importance, Mr. Bertrand Russell, is distinguished as a mathematician whose main endeavour has been to divorce mathematics from the facts of experience, and apparently he attempts to follow the same system in practical politics. Here, again, history repeats itself in curious fashion, since Laplace was charged by Napoleon with bringing into the administration of the office to which he was appointed the spirit of those infinitesimals to the study of which he made so many contributions of first-rank importance.

We are also frequently assured that after the war the fatal policy of restricting output will be abandoned by the working classes, and, undoubtedly, unless production can be greatly increased the whole standard of living in these islands must be most materially degraded. Looking to the past, however, and in view of the fact that every plan for increasing production has hitherto met with the uncompromising hostility of the men, Mr. Lanchester is more hopeful than sanguine as to this all-essential change of policy being accepted. This fear is not lessened by the continued declaration of certain of the men's spokesmen that "the hard-won rights and privileges" temporarily foregone at the national call must be restored *in toto* at the end of the war. Unfortunately, the class of publicist to whom we have already referred above, having accepted in *ante bellum* days at their face value German declarations of all sorts, whether as to their entire innocence of criminal intent or as to the superlative merits of their kultur, still guilelessly accept the foregoing claim, without inquiry into the real character of the so-called rights and privileges in question.

An instructive example, both as to the nature of these so-called rights and to the extent of the actual waiver, is afforded by a case tried in the munitions court at Stockton last September. In this case a union official was charged with fining a workman because he had spent but 5½ hours over a job for which the "recognised time" was 9½ hours. Mr. Lanchester contributes in his address another striking instance as to what these rights and privileges imply. Certain turret-lathe work, he states, was found to take much more time to execute than the nature of the job and the excellent special tools provided warranted. Changing the operator and machine effected no betterment, even when the work was done in different sections of the factory. At length one day, to meet an emergency, a number of the articles in question were made in the tool room, using an ordinary engineer's lathe and the ordinary equipment of tools. Evidently the men had never imagined that a special job of this character would ever be transferred to an ordinary lathe, and their carefully organised precautions to restrict the output failed accordingly. The result of the transfer was that the time taken per piece was less in these very unfavourable conditions than it was when the work was done on the turret lathe with every possible facility for rapid output. Of course, if the men insist on the letter of their agreement, the nation must keep to its bargain, but it should at least be clearly cognisant of the precise nature of the demand made.

Probably all workmen would admit as an abstract principle that in the long run the working classes are themselves the heaviest sufferers by the increase of costs due to such restrictions as the foregoing. If bricklayers and plasterers do *per diem* less than one-half the work reasonably due and less than one-tenth of the record rate, house rents must be correspondingly raised, and the accommodation available for a given rent diminished. The same rule obviously applies throughout, but the real difficulty lies in the fact that though in the ultimate outcome no class benefits more by the introduction of improved methods of production than the working classes, which in the aggregate are the largest consumers of all staple commodities, the immediate effect of such innovations on the individual workman may be temporarily disastrous. Employers, we fear, have given less consideration to this aspect of the question in the past than was wise.

Mr. Lanchester's logic may be unassailable when he declares that "it is an injustice that two men of equal industry, skill and ability, engaged and working under the same conditions, should receive one double that of the other." Logic is, however, but an inadequate guide to the conduct of life; and some further considerations are apposite. Many years ago, for example, certain flanged plates required in large numbers by a firm were made by skilled smiths at a net cost of some 10*s.* a piece. A special machine was then put in to do the work, and was operated by a labourer who, at a piece rate of a few pence per dozen, made what was possibly reasonably fair pay for a labourer, but was much less than the rate paid to any one of the many men he replaced. In this instance the gain was so large that there could be no financial disability in the matter of paying the operator at least as much per week as was paid to one of the hands superseded, and had this been done the innovation would, we believe, have rankled less and the organised opposition to further improvements would have diminished.

The experiment, now being tried by Mr. Ford, of paying his men at rates very materially in excess of those current in the open market is, we conceive, of great importance in this connection. For the current rates the employer purchases at present the use of the workmen's muscles, and but little more. His mind remains in the main at his own disposal, and is, as matters stand, even more frequently used for hindering than for promoting progress. The ultimate success of Mr. Ford's scheme depends on whether or no the workman will be more ready than before to direct his thoughts to helping the management in the direction of improving output and reducing waste, and some years must elapse before either a decided negative or affirmative can be returned as answer. The demand for equality which so many assume to be the strongest of the passions of the proletariat is, we imagine, less deep-rooted than would be gathered from the declamations of labour leaders. Some of the latter, no doubt, have denounced the Ford experiment as a return to feudalism, but there is little evidence that the rank and file of the workers resent the special advantages of the Ford employees.

In these days of a demand for "equality of sacrifice," by which is to be understood the claim that whilst all classes take an equal share in the risks of active service the well-to-do are in addition to be taxed out of existence, some considerations advanced by Mr. Lanchester are peculiarly timely. Owing to the fact that some exceptional individuals have had the self-restraint to save, implements have been provided by the use of which the average man gains a living with less effort than at any past period of human history. Curiously enough, the man who risks his whole fortune in the attempt to create a new industry, unlocking fresh sources of wealth, is denounced as an exploiter, an epithet which, whatever its implication, is for the most part avoided by the cautious unenterprising investor in municipal or Government securities. Whilst in speech the investor in industrial securities is denounced for profiteering, in practice, as Mr.

Lanchester acutely observes, the workman considers the return as far too small to tempt him.

Somebody or other has, in fact. to find a sum averaging about 200*l.* a head for each workman employed in manufacturing industries. Such a sum is not beyond the capacity of a healthy young man engaged in the skilled trades to save before middle life without any inordinate degree of self-restraint; but the prospect of being their own capitalists has never yet proved particularly seductive to our working classes. In fact, Mr. Lanchester observes that whenever the investments of trade-union funds in railway stock, or the like, amount to 5*l.* per head, industrial troubles in that particular trade may be anticipated with considerable certainty. The reason given by the men is that, owing to the low rate of return (which when received by others is denounced as inordinately great), the sums so invested are, to use the workman's phrase, "doing nothing."

Probably in their reluctance to become their own capitalists workmen are wise. Investors in this country have been somewhat reluctant to support adequately the so-called non-productive services on which the efficiency of every factory is all-dependent, and judging from the rate of remuneration the unions deem adequate for the men they employ to think and organise for them, matters would be hopelessly worse under proletariat proprietorship. Of course the whole subject of economics has been aborted *ab origine* by the failure of writers of all schools to recognise the predominant part played by mind in the creation of wealth. No doubt such a recognition would greatly complicate the science, as it would involve, amongst other matters, a distinction between intrinsic and exchange values. Faraday's researches on electro-magnetic induction had, for example, a high intrinsic value at the very outset, but their exchange value was for long extremely small.

THE NAVAL WAR AND THE SIZE OF BATTLESHIPS.

By William Hovgaard, Brookline, Mass., U.S.A.

The development of modern battleships exhibits a persistent and universal tendency towards an increase in displacement, caused by the ever-growing demands of naval men to improve nautical and military qualities. At times this movement has been arrested by technical improvements—in the manufacture of armour, in the design and construction of machinery, in the choice of fuel, &c.—which have allowed a saving in weight. But more frequently the movement has been checked by a reluctance to spend large sums on individual ships and by a fear of an undue concentration of risks.

Such checks in the evolution were indeed only temporary. Soon the designers had to resort to the old remedy of increasing the displacement, which enabled them without difficulty to augment the power of the battery and to carry a greater store of ammunition, fuel, and other supplies, and at the same time to enlarge the living spaces. These advantages, however, were of a quantitative nature and could not by themselves explain such a policy, since they could be attained by simply multiplying the number of units, maintaining the displacement of each unaltered. It is clear that the growth in size must have been accompanied by other more important and intrinsic advantages, inherent in larger vessels and not subject to addition.

There is no difficulty in building much larger battleships than those now existing, and it is easy to show that larger vessels, within rather remote limits of size, are in nearly all respects technically superior to smaller, but the problem cannot be solved on purely technical grounds. It is bound up with political, financial, strategic, tactical, and hydrographic conditions, all of which have to be considered.

In the following we shall attempt to take all these factors into account, but, in view of recent advances in submarine warfare, it is necessary first to show that battleships, as well as battle-cruisers, are still indispensable and capable of holding their own against submarine attack. Submarine dangers, moreover, are of particular interest in the present study, because they must be taken into consideration in every stage of the discussion on the size of battleships.

Battleships and Submarine Attack.

Barely ten years ago the submarine, after a long period of experimental work, reached the point where it became serviceable as a warship. It soon assumed a place as an integral part of the naval forces of all maritime countries, and a great number of boats of increasing size and power were built under steady improvement of details. At the same time destroyers, which had shown their offensive value in the Russo-Japanese War, were being rapidly developed, and great efforts were made to perfect and complete the outfit pertaining to the use of submarine mines. Many contended that the days of battleships were over.

Naval constructors were not blind to the dangers that threatened the security of battleships as a consequence of this development. Experiments were made in several countries to determine the best means of protection against submarine attack, and various special features of construction were adopted for this purpose. A number of vessels, moreover, were fitted out as mine-sweepers. These measures, however, did not keep pace with the growth in the efficiency and power of submarine weapons, and when the present war broke out, battleships, and indeed all large warships, were at a serious disadvantage in all seas where submarines and mines could be employed. The preventive and protective preparations against submarine dangers, dictated to some extent by experiments and by experiences gained in peace manœuvres, but based chiefly on theory and imagination, proved entirely inadequate. The realities of war took the place of imagination, and acted as powerful stimuli in the efforts for defending and protecting battleships and all other vessels liable to submarine attack. England, in particular, had to protect at any cost her trade and transports as well as the patrolling and blockading warships. The Admiralty at once took vigorous measures and made use of all available means, however imperfect and improvised they might be at first, in order to combat the submarine dangers. New methods and means of attack and defence were devised. Small, fast patrol vessels of special design were constructed in great number, and it appears that an extensive use was made of entanglements, wire netting and seining. Seaplanes were perfected and multiplied and the number of mine-sweeping vessels was enormously increased.

These measures soon had a damping effect on the submarine warfare carried on by the Germans in the waters surrounding the British Isles, but it must be noticed that at the outbreak of the war Germany possessed at the most 40 submarines, most of them too small for service outside the North Sea. This number, although later very considerably augmented, was entirely inadequate for the attempted operations, which had for their main object the strangulation of the maritime trade of Great Britain.

In the war against submarines the active or offensive means of defence seem to have proved, as usual, the most effective, but also passive means of defence were vigorously developed, chiefly in safeguarding by means of mines and nets the entrances to naval ports or anchorages and the most important areas of coastal waters. In the design of warships it is said that new structural features were adopted, but details are unknown.

Although the efforts to defeat submarine attacks have been on the whole successful, battleships are still forced to operate with the greatest caution in narrow seas where enemy submarines have a base. In the Heligoland Bight action, August 28, 1914, the British battle-cruisers, which acted as support for the flotillas, kept well in the rear in order to avoid submarine dangers, and did not take part in the action till their assistance was required. While thus waiting, they were attacked by three submarines, and avoided the attack only by rapid manœuvring. When called in support of the lighter vessels, they proceeded at full speed but, finally, had to abandon pursuit of the enemy due to the reported presence of floating mines to the eastward. Again, in the battle of the Dogger Bank, it was the dangers from German submarines and mines that ultimately prevented further pursuit of the German battle-cruisers. In the Mediterranean, at the beginning of the war, the number of submarines at the disposal of the Central Powers was much smaller than in the northern seas, and the artillery vessels of the Allies were able to take an active part in the operations. Thus, in the attack on the Dardanelles, battleships were at first freely employed, but in May, 1915, German submarines commenced to appear and the more modern and valuable battleships of the Allies were at once withdrawn. Later, when the Triumph and Majestic were destroyed by a submarine in spite of all possible precautions, the older battleships were ordered to take shelter, except when they were required for bombarding the enemy's works. There can be no doubt that if the number of submarines in the Mediterranean were sufficiently increased, the condition would be much the same as in the North Sea and the Baltic. On the other hand, it must be admitted that submarines themselves are exposed to the greatest dangers when operating in waters that are under the surveillance of a vigorous enemy, and that they have failed so far in obtaining control of such waters. The North Sea, the Baltic and the Mediterranean are in fact at the present time under the immediate control of various classes of light, fast surface vessels, and are ultimately under the domination of large armoured artillery ships, as evidenced in the battle of Jutland.

On the ocean, at a distance from the coasts, the large seagoing artillery ships, aided by light cruisers and destroyers, are still uncontested masters. This is proved by the fact that the British Navy is to-day in command of the high seas in virtue of its superior battle-fleet, which acts as a latent, potential power. It is owing to this power, which so far has been required to exert its energy but once, that the German flag has disappeared from the ocean and that the German fleet is imprisoned in its ports. British cruisers, which German submarines have been unable to drive into port, are patrolling all the seas, protecting the trade routes, while patrol vessels guard the home waters at points where routes converge. Occasional raiders are destroyed or driven into port, not by submarines, but by surface vessels. The mastery of the sea and the maritime connections of Great Britain are thus maintained, essentially by means of vessels armed with artillery and in spite of the energetic, skilful, and ruthless submarine warfare carried on by the Germans.

The question now to be considered is, how long this hegemony of the artillery ships is likely to last. It is certain that the number of submarines will be immensely increased in the future. Boats of larger size and better seagoing capability will be built, speed and endurance will be improved, and the day will undoubtedly come when submarines will be able to operate everywhere on the ocean and keep the sea for more extended periods. It is impossible to say when this point will be reached, but so far the development towards larger seagoing types of submarines has been relatively slow, chiefly on account of the difficulties of providing satisfactory propulsive engines of sufficient power on reasonable weight. It must be admitted, however, that this problem may be solved sooner than is expected, perhaps in the near future, and our judgment as to the utility of battleships must be based on this possibility.

Battleships must then operate on the ocean under the same precautions as now employed in the narrow seas. They will venture outside their safe ports only when their presence is required to fight the enemy's artillery ships. They will go at high speed whenever they are threatened by submarine attack, and must be guarded by screens of light vessels of various types and probably also by aircraft.

Submarines, on the other hand, due to the inevitable hardships of service on the ocean, will have relatively small endurance. If the field of operation is at a great distance from the base, the time of effective service will be much curtailed and the risks from breakdown of machinery or other accidents, when such boats are unaccompanied by surface vessels, will be immensely increased. Hence, in order to carry out an effective submarine blockade or patrol service over an extended area, a very great number of boats is required, and the wastage is apt to be considerable. With submarines on their

present standpoint, it would be impossible, for instance, for any European power not in possession of advanced bases to maintain a tolerably effective submarine blockade of the Atlantic coast of the United States, even if a very great number of boats were available for this purpose. Such service would be at the best in the nature of raids.

Let us now consider the problem from a tactical point of view. Submarines will always have relatively slow speed, especially when submerged, and it will be far more difficult for them to get into position for attack in the open sea than in congested channels or at points where trade routes converge. When they are submerged with only the periscope above the water their range of vision will ordinarily be very limited. When they are in the surface condition they are liable to detection by destroyers or other light and fast vessels, which will be employed to escort the artillery ships and probably also to convoy transports and important merchant vessels. That the airship and seaplane service for scouting and detection of submarines will be developed to higher perfection seems as certain as that the use of submarines will be extended. Once a submarine is detected, it will be attacked with shell fire, bomb-dropping, ramming, and seining, while the large surface vessels, whether warships or merchant ships, may, if desired, withdraw to a safe distance. Since submarines are unable to carry armour protection of anything but the lightest description, they are very vulnerable to artillery fire.

Summing up, it appears that submarines, even if developed considerably beyond their present standpoint, have small chances of carrying out successful attacks on well-guarded battleships on the ocean. The development of the submarine, moreover, is likely to be very gradual and will be, at least to some extent, matched by progress in the active and passive means of defence at the disposal of the artillery ships. It is concluded, therefore, that the submarine, although an important type of warship, will not for some time to come be able to drive the seagoing battleship from the ocean. It is not asserted, on the other hand, that this will never come to pass; in fact, unexpected technical improvements may some day bring about this result, but it would be unwise to base the naval policy on such an uncertain contingency, which may perhaps never be realised. Basing our judgment on the actually existing conditions in conjunction with the history of the previous development and recent war experiences, it appears that the seagoing battleship must yet for some time to come remain the supreme type of warship with all naval Powers, for whom command of the ocean is under certain circumstances a necessity.

(To be continued.)

NOTES.

The Proposed Organisation of Workers in Iron and Steel.

The committee of Scottish iron, steel, engineering, shipbuilding and allied industries appointed last August to consider steps for better organisation has now issued its report. The committee assumes that the Government will in future take a more active part in encouraging industrial development, and lays stress upon the all-importance of increased productivity. It is recognised that this aim cannot be obtained without the willing co-operation of labour, which will, accordingly, be solicited. A central organisation is proposed, to furnish Government departments with data and to maintain a propaganda for educating and informing public opinion. This body should, it is proposed, comprise representatives both of masters and men, and its meetings should be presided over by a Minister of Industry. For special purposes Government departments may also, it is suggested, be represented on this committee. The proposed Minister of Industry should, it is held, be associated neither with the employers' nor the workmen's side of the industry, and the individual appointed should not have merely a legal or a political qualification, nor should his appointment or retiral be dependent on changes of Government. In the meantime a temporary committee is to be appointed to take further steps towards ascertaining how far these preliminary proposals are likely to meet the requirements of the case.

Graphite as a Cylinder Lubricant.

Some 20 to 25 years ago many engineers thought that they had solved the problem of cylinder lubrication by the use of powdered graphite instead of oil. Graphite was found to have excellent lubricating properties, it would withstand unchanged the highest temperatures reached in a steam engine cylinder, and had no bad effect on the boiler if passed into the latter with the feed. Experience, however, whilst confirming all the good qualities of the graphite lubricant, added one of a contrary character, viz., the tendency of the powder to collect in ports and passages, and behind piston rings, blocking up, in short, any opening or cavity to which it could gain access. This drawback proved so serious as to lead to a return to cylinder oil, in spite of the difficulty of excluding it from the boiler. The impression thus made has naturally handicapped subsequent advocates of graphite lubricants, as it was necessary to convince possible users that the difficulty above-mentioned had been overcome, and no adequate demonstration could be afforded by a short time test. Special interest attaches, accordingly, to a paper recently read before the Birmingham Association of Mechanical Engineers by Mr. W. E. Johnston. In this paper the author stated that "Aquadag" had, since February, 1912, been used as the sole cylinder lubricant for a plant consisting of three 50-kw. high-speed steam dynamos, two deep bore-hole pumping engines, and various subsidiaries, all working with steam supplied at 120-lb. gauge pressure by three Lancashire boilers, unprovided with a superheater. During five years of almost continuous working which have since elapsed there has been, it is stated, no trouble whatever, either from clogging of passages, the presence of graphite in the boilers, or from inefficient lubrication. All rubbing surfaces have remained in excellent condition, and the slide valves, in particular, are without a trace of scoring. The boiler surfaces are clean down to the metal and entirely free from any suspicion of pitting. As most engineers know, "Aquadag" is a colloidal solution of graphite in water. The particles of graphite are so minute that they remain in a permanent state of suspension, just as has done the colloidal solution of gold preserved at the Royal Institution, which was made by Faraday nearly half a century ago. The constituent particles of a colloidal solution all carry and maintain an electric charge, and it is this charge which prevents the particles from coagulating. Their diameter is so small that they pass readily through the finest filter paper. If, however, the charge on the particles is destroyed by the addition of a little acid or other suitable electrolyte, the particles coagulate and deposit, and can, moreover, then be readily filtered out. This point requires to be borne in mind when dealing with all colloidal solutions. To ensure an even supply of the lubricant to his engines, Mr. Johnston has devised a simple form of sight-feed lubricator in which the "Aquadag" passes up, drop by drop, through a column of paraffin oil.

Potash from Rocks.

The enormous rise in the prices of potassium salts, which last winter exceeded in the United States more than 10 times the pre-war rates, has given a powerful stimulus to the efforts for utilising all available potassium sources. We recently referred to the revival in the kelp industry, the extraction of the potassium salts contained in certain tangs, which is conducted on the Pacific coast in a more systematic, yet apparently not much more remunerative way than on our shores. During the last decade attempts to utilise the potassium of minerals like feldspar and mica, which make up granite, porphyry, gneiss and other rocks, have been multiplied, especially also in the United States. All these minerals are insoluble, and are complex silicates containing potassium and aluminium in addition to greater or smaller percentages of other metals, none of which can, apparently, be isolated and extracted except by indirect and mostly expensive operations. Yet the natural decay of feldspar, &c., yields clay and alumina, while the alkali salts are carried away, mostly as carbonates probably. The time factor is very important in this disintegration and decay, which is the result of atmospheric attacks by rain, frost, sunshine, carbon dioxide and of other slow chemical reactions, and the point is to accelerate these reactions in the laboratory and in works. Dry heat, steam under pressure, alkalis and acids, lime, fusion with ores, cement, blast-furnace slag, sulphates, phosphates, &c., have been tried with more or less success. There are many partial solutions of the problem, but none seems economically satisfactory so far. According to Drs. B. Neumann and F. Draisbach, of the University of Breslau, the chances of competing against the natural potassium salt stores are unfavourable. Their articles (in the *Zeitschrift für Angewandte Chemie* of August 15 and 22, 1916) are useful, because they give a long list of the many processes suggested and patented and of the literature on the subject, and because they describe a comprehensive series of experiments on the yields of many reactions which they investigated. But we need not accept their conclusion, though we are far from advocating on general grounds the manufacture in works of products which nature supplies. The experiments of Neumann and Draisbach were made mostly with a Norwegian feldspar containing about 10 per cent. of potassium oxide K_2O. Not more than 5 grammes of the mineral, more or less finely ground, were used by three methods: (1) Heating with water and chemicals in an autoclave at pressures up to 12 atmospheres; (2) dry heating with chemicals; (3) heating about 750 deg. C., with or without chemicals, so as to volatilise the potassium salts. The chemicals tried were lime—slaked or not, alone or with other reagents—common salt, calcium and magnesium chlorides, caustic soda, hydrochloric acid (as dry HCl gas or aqueous acid), &c. In many cases the yields of potash were poor. On the whole, dry heating gave better yields than the autoclave, and the authors find that potassium chloride begins to volatilise at 750 deg. C. and can practically be expelled at 850 or 900 deg., quantitatively so at 1,300 deg.; in this respect they differ from other observers like Lindblad, who maintain that some potassium is retained, with the formation of leucite minerals. The best results were obtained with lime and calcium chloride; equal mixtures of feldspar and of these two reagents yielded up to 95 per cent. of their potassium, heated to 650 deg. for three hours, whilst the mixture of Cushman and Coggeshall (100 feldspar, 20 lime and 20 $CaCl_2$) yielded only 47 per cent. at 750 deg. Neumann and Draisbach did not try blast-furnace slag, which might be utilised hot, on the spot. Perhaps in the future a refrigerating installation will form part of all big plants, and the disintegrating effects of repeated freezing and thawing will be utilised. Most of the processes tried were the more successful the finer the materials were ground, and freezing facilitates the disintegration of some rocks very much. In the United States the deposits of the many salt lakes of the West are also to be considered as sources of potash, as they are in Hungary, Russia and other countries. We should, in this connection, also draw attention to a very useful pamphlet of 47 pages on "The World's Supply of Potash," recently issued by the Imperial Institute. The chief occurrences and the processes for their utilisation are ably described and literature references given.

Manganese in the United States.—The imports of manganese into the United States in August were 76,721 tons, as compared with 81,942 tons in July. The total imports for the eight months ended September 1, 1916, were 395,686 tons, as compared with 145,003 tons in the first eight months of 1915, and 183,029 tons in the first eight months of 1914. American manganese ore imports are now considerably in excess of those of Great Britain.

All-Iron Railway Trains.—Steel carriages, long known in America, have recently been introduced into Germany. The first all-iron D (express) train has been running since September between Berlin and Cologne. It consists of five passenger carriages and a dining car. The carriages were all built by Messrs. Van der Zypen and Charlier, of Köln-Deutz; the bogies are of the Othegraven type and are said to run very smoothly. Wood is used only for the panelling of the walls and for the flooring.

LITERATURE.

A Study of Industrial Fluctuation: An Inquiry into the Character and Causes of the So-called Cyclical Movements of Trade. By D. H. Robertson, M.A. London: P. S. King and Son. [Price 7s. 6d. net.]

A study of this subject of trade fluctuations gained for the author the Cobden Club Prize, at Cambridge, in 1913, and its extension in its present form was equally successful in gaining the approval of the Electors to Fellowships at Trinity College, in 1914. It is, therefore, a pre-war work, dealing with principles underlying commercial action, and is independent of the upheaval of trade relations and accepted traditions. The problems that will arise on the restoration of peace, and which are at present engaging the attention of the captains of trade and industry, neither explain its appearance nor provide material for discussion. The author aims at probing the elemental causes capable of producing "booms" and depressions, and his scheme does not include the effects of sudden cataclysms or of superficial disturbances. He admits that the form in which he has presented his dissection of the many operations simultaneously at work is better designed to impress his examiners with the extent of research than to carry conviction to a more general public, and regrets that he has not been able to give a more pleasing setting to his conclusions. We share this regret. The annoyance of reading a work in which every few lines is interrupted by a footnote increases with every page turned, and the generous insinuation of references—limiting, extending, or explaining statements made in the text—adds to the difficulty of following a sustained, but sufficiently complex argument.

The analysis which Mr. Robertson invites us to follow is interesting mainly as an academic inquiry. Though some suggestions of practical policy are submitted, we doubt their validity, for experience has an awkward trick of disproving the conclusions of economists. When fate arranges the pieces of the commercial chessboard in situations which have some great similarity to the order of some previous problem, it is usually with the object of discovering a new, and not repeating the old, method of solution. So many authorities have been deprived of their pride of place that we may doubt if economic doctrine can be supported by rigorous demonstration that is alike beyond the pale of controversy and has nothing to fear from the lapse of time or changing social conditions. Is it remembered now that Ricardo founded a school that won wide acceptance and became a dominant force in social legislation? Yet to-day his teaching is so dead and effete that no English economist would do him reverence. Especially is it remarkable that it is precisely those propositions which lend themselves to practical conclusions, as, for example, the doctrine of distribution, that have been the most discredited. Jevons and Cairnes, from different sides, did much to damage a falling reputation, but these in their turn have also suffered from the advocates of new methods and new interpretation. Authority, it would seem, has little chance of longevity, and this want of stability and definiteness must be a great hindrance to the student of social and commercial economy. The orthodoxy of our age becomes the heresy of the next, and to rely on authority is to trust to a broken reed. The author enters into this shifting sand of conjecture and deduction, rather with the view of harmonising declared opinions than of suggesting new arguments or unassailable reforms. He reminds us that in the eighties 180 different causes had been assigned to explain the recurrence of crises and depressions that vexed the soul of commercial life; by 1895 the number had risen to 230, and by this time probably ingenuity has increased the number to 500. Further, within the last five years no less than six treatises have appeared to explain this perpetual seesaw, and still the subject is unexhausted. He intimates that each writer so much overweighs the importance of his own contribution to this vexed subject, and so undervalues the views of others, that no single comprehensive explanation holds the field. "It is the author's conviction that the most important work which remains to be done lies in the direction of developing and synthesising the various and often conflicting opinions which have been already expressed," and his contribution is made to that end; but that does not exclude original suggestion and illustration, which give to this work the quality of independence both in plan and argument. We fear the author will earn the thanks of few for his well-meant attempt, but his course is justified, for the more the nature of a crisis is understood, the more thoroughly its causes are analysed, the better its evils can be discounted and its worst effects mitigated.

The author rules out of discussion temporary financial crises, and considers only the occurrence of alternate periods of industrial expansion and industrial depression, terms that need very careful definition if one would see the issue precisely as it presents itself to him. The impression that one forms of an industrial depression is distinct enough, and to many the issue will be confused, rather than illuminated, by the author's attempt to explain his purpose more clearly by introducing the mysteries of "margins" and "utility values," clear indications of the school to which he belongs, but of little use in enabling us to penetrate to the heart of the problem. The alternate definition of depression as a period in which the consumption of investors is smaller than anticipated is more readily apprehended, especially if we are allowed to put our own construction on "consumption." Mr. Robertson objects to this definition on theoretical rather than practical grounds, but admits the impossibility of framing a definition that shall be "theoretically watertight, and in tolerable accord with popular usage." This may appear an impotent, but we believe a just, conclusion, and warrants the sly remark that it is not surprising "that no consistent and comprehensive explanation has yet been given of a problem, the precise nature of which it seems impossible to define."

We are quite at one with Mr. Robertson in considering the whole problem as worthy of analysis, and believe that nothing but good can come from letting light into the complex and wayward character of modern industry. Progress is not uniform, and the causes of disturbance are deep-seated and involved. The greater the number of the sources of dislocation, the greater the necessity for minute dissection. In the past there has been too great a tendency to consider the total effect without close examination of the contributory causes, and taking into account the impossibility of all originating and acting simultaneously. With imperfect methods of analysis there was little chance of detecting the special features which cause modern industry to progress by undulations. To invoke sun-spots or other cosmical phenomena, a suggestion that dates back to the time of Sir William Herschel, and which, revived in a modern and less crude form, is discussed here, is to overlook the influence of the necessary intervals of time—periods of gestation, as Mr. Robertson calls them—which separate the crests of prosperity, noticeable in different trades, that may be started by a common impulse, but require different periods for development. We should make little progress in our knowledge of tidal theory if we did not regard the observed tidal wave as the result of the superposition of many waves, all differing in phase and amplitude and period. The periodic fluctuations in industrial productivity and distribution resemble tidal phenomena in many particulars, but the analogy must not be pushed too far. The tide runs up an invariable beach, its height and recession are easily determined by fixed standards, but trade statistics and fluctuations have to be measured from a constantly varying datum. Each successive expansion or depression is referred to a different standard, it reacts on a different world, on which previous fluctuations have left their impression. This, however, is to pursue the obvious. Our object is simply to emphasise the thoroughness of analysis which marks Mr. Robertson's work, and his determination to follow the movements of trade whither they may lead. For methodical presentation the subject is divided into two parts: first, an inquiry into the causes of fluctuations in groups of industries, and, secondly, an attempt to determine to what extent the partial fluctuations explain the noticeable general fluctuation. The first investigation is subdivided into two parts: a consideration of the causes that affect supply, and those that must be sought in fluctuation of demand. The author sums up his conclusions in a final chapter, in which are offered some suggestions as to practical remedies. These will be regarded as not the least interesting portion of the book, and it is only from considerations of space that we refrain from discussing them. They include possible improvements in industrial structure, improvements in public knowledge, improvements in banking policy, and improvements in monetary mechanism.

The Mechanical Handling and Storing of Materials. By G. F. Zimmer, A.M.Inst.C.E. London: Crosby Lockwood and Son. [Price 42s. net.]

This work, which is written by an expert on a subject to which he has given much attention, could not have been published at a more opportune time. Too little use is made in this country of mechanical methods for handling materials at our ports and warehouses, with the result that the necessity for a poor class of casual labour is maintained, such labour being used intermittently to an enormous extent at our docks, railway depots and other traffic centres.

The treatise under notice is a very comprehensive one; on reference to the contents it will be found that an endeavour has been made to cover the subject completely; chapters being devoted to conveying, elevating, transporting, storing and reclaiming coal, coke, grain, wood, ashes, &c., by mechanical means, while the examples of the power arrangements required for driving the apparatus includes steam, electric, hydraulic and pneumatic appliances. Although the scope of the work is so large the sequence is well maintained, and with the additional assistance of an extensive index it is an easy matter to refer to any particular system or scheme.

The book will be useful for reference purposes in the office; it contains descriptions and illustrations of a number of actual plants, in fact a large section of the book is devoted to these; but in a great many cases the leading dimensions are not given, and, further, the scales are not included on such plates as have apparently been prepared from working drawings. The descriptions are good, but would have been more valuable if fuller information on the cost of the installations described had been included as well as the working and maintenance expenses. There is an opinion current in this country that both capital cost and the working expenses of this class of plant are high; this view is to some extent justifiable, and therefore fuller information on the point would have enhanced the value of the work. We fully realise, however, that information on such matters is difficult to obtain for publication, and we may fairly assume that its absence in the volume before us is not due to any fault of the author.

A large number of the schemes described are either of installations at work on the Continent or in the colonies, and it is to be regretted that so many of them have been designed and the plant made wholly or in part in Germany or in the United States of America. This can be attributed in a measure to the lack of appreciation of the services rendered by mechanical freight-handling appliances not only on the part of Government departments and port authorities, but by contractors generally in this country. The large railway companies in their docks, goods depots and workshops have been much more progressive, but even here delays in the expeditious loading and unloading of goods are not unknown, and it is very necessary that this state of affairs should be altered.

The installations described by Mr. Zimmer clearly show that Germany and the United States of America are in many respects ahead of this country in the development and use of all appliances for the handling of materials during transport; the question of an adequate supply of labour of the right kind has been a determining factor. Germany has aimed at training and utilising the employee for a more effective class of work, and in America high labour costs have given an incentive to the development and introduction of machinery and plants of this description; in any case both countries have given us a clear lead on the way to

proceed, and some of the schemes they have brought into use are distinctly bold.

It is to be hoped that in the early future every means will be adopted in this country for releasing unskilled and casual labour so largely used for unloading coal, coke, grain and all classes of goods into and out of warehouses, ships and goods yards, &c. The method by which this work is at present carried out is in many cases degrading, the physical strain is great and harmful, and the cost is often an unknown factor. The perusal of this book before us should make engineers who are responsible for handling goods study their respective problems and see that new methods are used in the future in order to reduce to a minimum (a most important point at the present time and probably more so in the near future) the number of manual labourers employed by them on their works. The capital expenditure necessary to provide mechanical appliances will have to be faced, but the savings to be effected are considerable and the advantages to the employer and the employee great, resulting in a net gain.

It is surprising that rope-ways have not been used more fully in this country on large contract work; the chapters in Mr. Zimmer's book dealing with this type of equipment are most interesting, and the particulars given of the schemes, some of which are unique, are complete. The single rope system is fully described.

The methods described of dealing with hot coke in gas works and the handling of coke from coke-ovens are also useful; a number of installations are described, but the author does not express an opinion on the possible developments. The real trouble with plants for handling such a material as coke is excessive wear of the chains, pins, bearings, &c., and it would have been of value if the author had given us the results of his experience on the question of maintenance.

The methods employed for disposing of ashes are dealt with in chapters specially devoted to the schemes used—(1) at sea, and (2) for power and other central stations. In the case of the former the methods and apparatus are generally well known, in the case of the latter the newer method of disposing of the ashes by pneumatic power is described and illustrated; only a few plants of this class have so far been installed in Great Britain, and the particulars given should be interesting to those who have to deal with this subject.

The author only allots a small space to the Telpher or overhead runway. As this is an economical and useful scheme for transporting coal and coke, particulars and descriptions of a larger number of existing plants might have been included, especially as the system can very often be installed in old and scattered works where other systems might be difficult, if not impossible. The question of obtaining wayleaves for overhead runways and rope-ways, the provision of private sidings and the supply of railway trucks has been in this country a difficulty in the past, but it is hoped that with the action which the Government have taken due to the war and the urgent necessity for promptness, a more reasonable attitude will be taken with those anxious to have proper facilities for the quick transit of their productions.

In the section dealing with the unloading of grain from vessels, &c., all the known systems are included under three main headings:—(1) The blast system; (2) the suction system; and (3) the combined suction and blast system. The three systems are described in detail, and full information, with illustrations, is included of Duckham's, Haviland & Farmer's and Mitchell's pneumatic elevators. There are some fine examples of such equipments, complete with granaries, in this country, and the list on pages 703 and 704 is a useful guide to the locality and type of granary. The author does not describe nor refer to the necessity for a small compact power-driven equipment for unloading grain and similar materials from barges; there are a number of small docks and depots in this country where such an appliance would be serviceable. In these cases the primitive jenny wheel, sack, sack barrow and line of men are to be found.

Chapter xliii of the book deals with a most important adjunct of the above-named plants—automatic weighing machines, but although the known machines are referred to, the particulars are too meagre. The mechanical transport of materials can be much handicapped unless the weighing apparatus is properly installed, maintained and periodically checked. These points must have careful attention if the machines are to function properly.

The publishers are to be congratulated upon the excellent manner in which the book is printed, the illustrations and plates are clear and the index is comprehensive. The names of German makers of this type of plant, however, might advantageously have been left out of the list in the trade directory.

BOOKS RECEIVED.

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United States Department of Commerce. Bureau of Foreign and Domestic Commerce. Statistical Abstract of the United States, 1915. Washington: Government Printing Office.

Columbia University. Faculty of Political Science. Studies in History, Economics, and Public Law. Volume LXVII, No. 2. Whole Number 162: State Regulation of Railroads in the South. By MAXWELL FERGUSON. [Price 7s.] *Volume LXIX. No. 1. Whole Number 164: Railway Monopoly and Rate Regulation.* By ROBERT JAMES MCFALL, Ph.D. [Price 8s.] New York: Columbia University; London: Longmans, Green and Co., and P. S. King and Son, Limited.

United States Bureau of Mines. Technical Papers. No. 93. *Graphic Studies of Ultimate Analyses of Coals.* By OLIVER C. RALSTON. With a Preface by HORACE C. PORTER. No. 129. *Metal-Mine Accidents in the United States during the Calendar Year* 1914. Compiled by ALBERT H. FAY. Washington: Government Printing Office.

United States Geological Survey. Mineral Resources Papers. 1914. I: 25. *The Production of Cobalt, Molybdenum, Nickel, Tin, Titanium, Tungsten, Radium, Uranium and Vanadium.* By FRANK L. HESS. I: 26. *The Production of Antimony, Arsenic, Bismuth, Selenium and Tellurium in* 1914. By FRANK L. HESS. I: 1. *Chromic Iron Ore.* By J. S. DILLER. I: 2. *Gold, Silver, Copper, Lead and Zinc in the Eastern States.* By JAMES M. HILL. II: 1. *Fuel Briquetting in* 1915. By C. E. LESHER. II: 2. *Sand-Lime Brick in* 1915. By JEFFERSON MIDDLETON. II: 3. *Fuller's Earth in* 1915. By JEFFERSON MIDDLETON. II: 4. *Asbestos in* 1915. By J. S. DILLER. II: 5. *Slate in* 1915. By G. F. LOUGHLIN. II: 6. *Fluorspar in* 1915, *with Note on Cryolite.* By ERNEST F. BURCHARD. II: 7. *Feldspar in* 1915. By FRANK J. KATZ. II: 8. *Silica in* 1915. By FRANK J. KATZ. II: 9. *Talc and Soapstone in* 1915. By J. S. DILLER. II: 10. *Abrasive Materials in* 1915. By FRANK J. KATZ. II: 11. *Graphite in* 1915. By EDSON S. BASTIN. Washington: Government Printing Office.

United States Geological Survey. Bulletins. No. 610. *Mineralogic Notes. Series* 3. By WALDEMAR T. SCHALLER. No. 618. *Geology and Underground Water of Luna County, New Mexico.* By N. H. DARTON. No. 619. *The Caddo Oil and Gas Field, Louisiana and Texas.* By GEORGE CHARLTON MATSON. No. 620–O. *A Reconnaissance for Phosphate in the Salt River Range, Wyoming.* By G. R. MANSFIELD. No. 621–E. *A Reconnaissance in Palo Pinto County, Texas, with Special Reference to Oil and Gas.* By CARROLL H. WEGEMANN. No. 621–M. *Geology and Oil Prospects of Cuyama Valley, California.* By WALTER A. ENGLISH. No. 621–P. *Analyses of Coal Samples from Various Parts of the United States.* By MARIUS R. CAMPBELL and FRANK R. CLARK. No. 623. *Petroleum Withdrawals and Restorations Affecting the Public Domain.* By MAX W. BALL. No. 626. *The Atlantic Gold District and the North Laramie Mountains, Fremont, Converse and Albany Counties, Wyoming.* By ARTHUR C. SPENCER. No. 628. *Geology and Coal Resources of Castle Valley in Carbon, Emery and Sevier Counties, Utah.* By CHARLES T. LUPTON. No. 629. *Natural Gas Resources of Parts of North Texas.* By EUGENE WESLEY SHAW, GEORGE CHARLTON MATSON and CARROLL H. WEGEMANN. No. 632. *Spirit Levelling in West Virginia*, 1896–1915. By R. B. MARSHALL. No. 633. *Spirit Levelling in Maine*, 1899–1915. By R. B. MARSHALL. No. 634. *Spirit Levelling in Louisiana*, 1903–1915. By R. B. MARSHALL. No. 640–A. *Notes on the Promontory District, Utah.* By B. S. BUTLER and V. C. HEIKES. No. 640–C. *Some Manganese Mines in Virginia and Maryland.* By D. F. HEWETT. No. 641–A. *Ozokerite in Central Utah.* By HEATH M. ROBINSON. Washington: Government Printing Office.

Oil Field Development and Petroleum Mining: A Practical Guide to the Exploration of Petroleum Lands, and a Study of the Engineering Problems connected with the Winning of Petroleum. By A. BEEBY THOMPSON, M.I.Mech.E. London: Crosby Lockwood and Son. [Price 25s. net.]

The American Petroleum Industry. Two Volumes. By RAYMOND FOSS BACON and WILLIAM ALLEN HAMOR. New York: McGraw-Hill Book Company; London: Hill Publishing Company, Limited. [Price 42s. net.]

Excess Profits (Including Excess Mineral Rights) Duty and Levies under the Munitions of War Acts. By W. E. SNELLING. Second Edition, Revised and Enlarged. London, Bath, New York and Melbourne: Sir Isaac Pitman and Sons, Limited. [Price 10s. 6d. net.]

Engineers' Costs and Economical Workshop Production. By DEMPSTER SMITH and PHILIP C. N. PICKWORTH. Second Edition. Manchester and London: Emmott and Co., Limited. [Price 4s. 6d. net.]

Fatigue Study: A First Step in Motion Study. By FRANK B. GILBRETH and LILLIAN M. GILBRETH, Ph.D. London: George Routledge and Sons, Limited. [Price 6s. net.]

The Elements of Engineering Drawing. By E. ROWARTH. With numerous diagrams. London: Methuen and Co., Limited. [Price 2s. 6d. net.]

Wire and Sheet Gauge Tables. A Metal Calculator and Ready Reckoner for Merchants and for Office and Shop Use in Sheet, Plate and Rod Mills and Forges. By THOMAS STOBBS. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 3s. 6d. net; post free (U.K.) 3s. 10d.]

The Construction of Roads and Pavements. By T. R. AGG. New York: McGraw-Hill Book Company; London: Hill Publishing, Limited. [Price 12s. 6d. net.]

AUTOMATIC HACK-SAW GRINDER.—In our issue of November 10 last we illustrated and described an automatic hack-saw grinder constructed by the Wardwell Manufacturing Company, of Cleveland, Ohio. We have since learned that this machine can be obtained in this country from Messrs. Honeywill Brothers, of 79, Mark-lane, E.C.

ASBESTOS ABRASIVES, SILICA AND SAND LIME BRICKS IN THE UNITED STATES, 1915.—The asbestos produced in the United States in 1915 amounted only to 1,731 short tons, valued at 76,952 dols.; but the increase over the previous year in bulk was 39 per cent., and the increase in value over 300 per cent., the latter part being due chiefly to the mining in Arizona of chrisotile, an asbestos of the cross-fibre type which can be spun. So far asbestos had been exported from Canada to the United States free of duty. In March, 1916, however, Canada put an embargo on shipment of asbestos to ports other than British and Allied; the embargo has since been modified, but American miners have been looking round, especially also in Vermont, the asbestos of which occurs in the same rocks as in Canada. Somewhat similar relations hold for abrasives. We take our information from articles compiled by J. S. Diller, F. J. Katz and J. Middleton in "Mineral Resources of the United States, Calendar Year 1915." The production of abrasives increased by 33 per cent., the imports decreased by 26 per cent. The term abrasives comprises millstones, grindstones, oil-stones, &c., emery and corundum, diatomaceous earth, kieselguhr, tripoli, pumice, and also diamond dust and bort. In value the emery and corundum exceed all the other products by far, and the low imports are primarily ascribed to the unsettled conditions in Turkey and Greece and to the war in general. Westchester County, New York, supplies most of the emery. Tripoli is the porous, almost purely siliceous rock resulting from the leaching of highly siliceous limestones or of highly calcareous cherts. By silica the statistics of the United States Geological Survey understand quartz, sand, flints and some of the abrasives just mentioned, all these materials being used in pottery and glass-making, as flux, and as fillers in acid towers, paints, soaps, &c. Sand-lime bricks are coming more into favour; nearly 180,000,000 of these bricks were made in 1915 and valued at 1,135,104 dols.; the State of Michigan leads in this industry.

THE ORDNANCE SURVEY.—Colonel Close, Director-General of the Ordnance Survey, reports that in the levelling of the past year it was noticed that the levelling towards a mark tended, as a rule, to give too low a value to the height of that mark. Thus when a line is levelled in both directions between A and B, the levelling from A to B tends to lower the height of B or raise the height of A and the levelling from B to A tends to lower the height of A or raise the height of B. The tidal observatory at Dunbar has now been in operation for three years, and that at Newlyn for one year. The mean height at Dunbar for the year ended April, 1916, was about 0.01 ft. less than the mean for the preceding year. The monthly mean for the year was 0.939 ft. at Dunbar, and 0.981 ft. at Newlyn. The magnetic survey was continued up to the end of August, 1915. The observers were then withdrawn, leaving seven stations in the western islands of Scotland still to be visited and observed from at a more convenient time. In all, the transfer of the triangulations of nine counties has been completed, and the work of transferring the triangulations of Huntingdonshire and Suffolk is now in hand. In 1837–38 a line of accurate levelling was executed by Mr. Bunt in order to compare the mean sea level of the Bristol Channel with that of the English Channel, and also to enable subsequent levelling to determine whether there had been any vertical movements of the land surface. The work was undertaken for the British Association under the direction of Dr. Whewell, who reported that at several meetings of the Association it had been suggested that the exact determination of the relative level of three points considerably distant from each other on the coast of the island might throw light upon several important questions, particularly as to how far the position of the earth's surface is permanent. After the lapse of 78 years the line was carefully re-levelled in 1915–16. The survey shows that for a length of 58.87 miles between Perry Farm and Axmouth the difference was 1.12 in. Between intermediate points the differences were slightly greater. The general result of the comparison is that there is no indication that there has been any change in the relative levels of the coastlines of the Bristol Channel and English Channel during the last 78 years.

THE LATE MR. ARCHIBALD COLVILLE.

Eight weeks ago we recorded the death of Mr. David Colville, the managing director of the well-known Dalzell Steel Works, Motherwell, and to-day it is our regretful duty to place on record the death of his elder brother, the chairman of the company—David Colville and Sons, Limited—and the last surviving son of the founder. The death of Mr. Archibald Colville, following so soon after that of his brother, intensifies the loss, not only to the firm, but to the steel industry of Scotland, in which both of them took such a prominent and useful part. Mr. Archibald, like his brother, had played a strenuous part since the outbreak of the war in the work of providing steel in all forms for the supply of the fighting forces, and in both cases the strain was in large measure the cause of death. Mr. Archibald Colville contracted a cold a fortnight ago, which developed into pneumonia, and he died at his Motherwell residence, "The Moorings," on the 11th instant, in his 64th year.

The subject of our memoir entered, at the age of 17 years, the offices of Messrs. James Finlay and Co., one of the best-known firms of East India merchants in Glasgow, but in the following year (1871), when the Dalzell Iron Works were formed by his father, he entered the business, and from that date was an important factor in the success of the undertaking, devoting himself largely to the commercial side of the business. It was mainly at his instigation that the firm took over the Glengarnock and Clydebridge Iron Works, in order further to increase the output of munitions. While leaving the technical control of the business to his two brothers, he, by his shrewd commercial ability, enterprise and integrity, did much not only towards the development of the business, but the improvement of steel. He was looked upon by his confrères in the steel industry as a man of great organising ability, and was chairman of the Scottish Steel Makers' Association as well as a member of the Board of Trade Iron and Steel Industries Committee. For 11 years he was a representative of the harbour ratepayers on the Clyde Navigation Trust, and a deserved compliment was paid to his discrimination and experience by his election as convener of the Committee on New Works and the Maintenance of the River and Harbour. He was elected a member of the Iron and Steel Institute in 1895. He played the part of a captain of industry in the town of Motherwell, where the works are situated, bringing to bear upon it sterling qualities. Thus he was chairman of the Licensing Appeal Court and a Justice of the Peace, and took a practical and philanthropic interest in the Church and other affairs. His death, therefore, is much regretted, and his widow, two sons and five daughters have the sympathy of a great many professional and private friends. His eldest son, Captain David Colville, is a captain of a Scottish yeomanry regiment; he took part in the campaigns in Gallipoli and Egypt and was mentioned in despatches, but the Government authorities some time ago came to the conclusion, very properly, that he could better serve his country by returning to the Dalzell Works in order to maintain, and if possible to augment, the output of steel.

The Slide Rule.—We have received a copy of a little pamphlet on the slide rule which has been prepared by Mr. A. L. Higgins, A.M.Inst.C.E., and, until he left for active service, demonstrator in engineering at the Queen's University, Belfast. The pamphlet describes in detail the usual Gravêt type of rule and the methods of using it. The publishers are Messrs. Whittaker and Co., London, and the price of the booklet, which will unquestionably be found useful by many students, is 4*d*.

Coke Fuel for Electric Power Stations.—The Highways Committee of the London County Council have placed an order for eight coke-burning mechanical stokers for use under the steam boilers at the Greenwich generating station. It is calculated that the first sets of stokers now contemplated will, if worked to their full capacity, consume 100 tons of coke per 24 hours; and having regard to the relatively high cost of coal, as well as the relatively greater degree of efficiency attainable in burning coke, every effort will, no doubt, be made to use the new stokers to their fullest capacity.

Pears' Shilling Cyclopedia.—A copy of the 20th edition of this very useful work has reached us. It contains over 1,000 pages of small type, all of which are packed with information. The book is divided into 20 sections, including a dictionary of the English language, a dictionary of general information, a dictionary of prominent people, and a classical dictionary; a compendium of everyday information, a gazetteer, an atlas, a chronological history of events; sections on gardening, poultry, cookery, health, sports, toilette, nursery, business, photography, motoring, domestic pets, and a ready reckoner. It is quite clear that the book could not have been produced for the price of 1*s*., which is charged for it. It is quite possible to spend many times this sum over books of reference without getting an equal amount of information.

TESTS ON A DIESEL ENGINE.

To the Editor of Engineering.

Sir,—In your issue of the 8th inst., page 566, you print a letter from Professor Burstall in which he mentions that the engine on which the tests referred to were made was tuned up by the Diesel Company; meaning, I take it, the late Diesel Engine Company, Limited, of London. As I was a member of the staff of this company for a number of years I shall be glad to be allowed to make a few comments. Before doing so, however, I should like to express my appreciation of the research conducted by Lieutenant Wilkins, which I consider a valuable contribution to the science of the subject in spite of the fact that the engine under test was not tuned up to the best of its capabilities apparently.

In the first place I should like to state that no engineer of the Diesel Engine Company would consider an engine properly tuned up if a mean indicated pressure of 86 lb. could not be exceeded without smoke. In the majority of cases engines based on a mean indicated pressure of 100 lb. per square inch would give an overload of 20 per cent. without smoke. In any case it is to be presumed that the engine received adjustments to the fuel valve in the period elapsing between its installation by the Diesel Engine Company and the date of the tests.

In the second place, I should like to refer to a paper read by Professor Dalby before the Institution of Naval Architects on April 2, 1914, and reported in your issue of April 10 of that year. In this paper Professor Dalby records tests on an engine of the same cylinder dimensions as the engine under discussion, namely, 165 mm. by 270 mm., also made by the Augsburg firm, and, I believe, similar in every essential particular to the engine at Birmingham. Professor Dalby obtained a mean indicated pressure of 118 lb. per square inch.

I will not labour the matter further, as the two tests can easily be compared by anyone interested in the matter, and my only object is to support Mr. Mickelsen in dispelling misconceptions about a prime mover, the development of which in this country has already suffered too heavily from ignorance and prejudice.

Yours faithfully,
H. F. P. Purday,

147, Abbey-road, Barrow-in-Furness,
December 9, 1916.

"SPARK IGNITION."

To the Editor of Engineering.

Sir,—Replying to the query raised in Mr. Edmunds' letter in your issue of the 1st inst. I would suggest that because the majority of car manufacturers mentioned fit battery ignition, this is no proof of its efficiency, but rather that it is less expensive on account of the necessary accumulator being already installed for starting and lighting purposes.

Where the gilded god "Production" is concerned, efficiency is quite a minor matter, for evidence of which the same manufacturers fit external contracting band brakes, inaccessible valves and other monstrosities.

Your correspondent having quoted the *Autocar*, I would refer him to the account of an instructive race meeting, in the issue of October 7, in which the winning car was practically rebuilt, many of the "Production" manufactured parts being replaced by those of known efficiency, with the result that little of the original car was left after the alterations and replacements, among which the standard ignition was replaced by a magneto.

Yours faithfully,
Acton, W. Wm. L. Gullette.

To the Editor of Engineering.

Sir,—I am afraid Mr. P. G. Tismer has not read carefully my article on "Spark Ignition." If he will re-read it he will find that it contains the reply to the main points in his letter. Such facts mentioned by him as are relevant to the subject are known to me, and are covered by the conclusions given in my article.

Regarding the word "incendivity," it is to be expected that it should excite adverse as well as favourable comment. I cannot understand the reason given by Mr. Tismer for regarding it as objectionable. He rightly says that "a spark of a given incendivity will ignite a good mixture but not a poor one," and then remarks that "it is not good practice to express in a single term two variable factors." If the latter quotation has any meaning it shows an entire misapprehension of the significance which I attach to the term. Incendivity refers to only one variable, and that in the spark.

It must be evident to anyone who seriously tries to think out the problem of spark ignition that the term incendivity or some other having the same meaning is necessary for conveniently describing the ability of a spark to produce ignition. At present the term incendivity does nothing more, and its sole function is to avoid repetition of a string of words. "Heat content" is sometimes used, but this is objectionable, for the reasons that ignition does not depend wholly, if at all, on heat content, and it inplies that ignition is due to the heat of the spark, whereas it may ultimately be proved that heat has nothing to do with ignition. The terms "strength" and "intensity" are also objectionable, because they suggest nothing, and are equally applicable to other properties of a spark which do not affect ignition. Without reference to any theory of ignition the fundamental fact is that a spark possesses a property by which it can ignite a combustible gas, and as there is no other useful word which expresses this property the term incendivity meets the case. Further, it has the advantage that it suggests its own meaning without implying a false assumption, and is adaptable to a quantitative definition when such can be given.

Regarding the statement by Mr. Tismer that heat and temperature are synonymous terms, I need only refer him to any elementary school book on physics.

The statement: "A perfect gas almost any sort of a spark will ignite—a well-known fact," is illogical and untrue. Presumably what is meant by a perfect gas is a mixture of given constituents which is most readily exploded. As is known to those who have scientifically investigated this matter, such a mixture requires a spark of definite incendivity for its ignition. The "repair men," to whom I can imagine Mr. Tismer would more readily refer his scientific problems for elucidation, were quite right in their statements that they had succeeded in getting ignition with 12-volt coils where 6-volt coils had failed. I give the scientific reason for this in my article. They might also have succeeded with another 6-volt or even a 4-volt coil if they had tried a sufficient variety of makes or had known sufficient of the ignition problem to be able to design proper coils themselves.

If Mr. Tismer and other practical men will look at their ignition problem from the point of view I have tried to explain they will find that their varied and otherwise irreconcilable experiences become quite coherent and intelligible.

Yours faithfully,
J. D. Morgan.

13, Temple-street, Birmingham, December 11, 1916.

"CLEATOR AND CLEATOR MOOR."

To the Editor of Engineering.

Sir,—I esteem very highly your most generous notice of my book, "Cleator and Cleator Moor," and I hope your able reviewer will not regard my act as wanting in gratitude if I beg leave to point out one little slip.

In the review, col. 1, lines 5 and 4 from the bottom, there is the phrase: "deposition in fissures by some process of igneous injection." This should read, "deposition in fissures through filtration or evaporation" (*vide* p. 201 in the book under review).

I made this reservation *re filtration* because I have repeatedly found, both in quarries and in mines, large fissures filled with stiff clay, of a blood-red colour, highly charged with hematite. There can be no doubt that the hematite had been carried in by the action of water.

Cleator, December 9. Cæsar Caine.

[The Rev. Cæsar Caine has not expressed his views very clearly. With his explanatory note before me, I am unable to decide whether he regards the action of water as sufficient to explain the occurrence of hematite in the district, or simply as an agent in effecting local distribution. As affecting the work, the point is immaterial, for the object of the author was not to write a treatise on economic geology, but a chapter in the history of social development.—The Reviewer.]

RELATIVIST.

To the Editor of Engineering.

Sir,—I have never said, nor do my words imply, "that there is no truth in either the electron, the quantum, or the relativity theories"; but I was careful to state:—"It is because of our serious study of what Relativists try to say that we question the soundness of their claims"; and, with all due respect, I submit that there is nothing in the long quotations from Maxwell and Thomson to substantiate those claims.

When expressing to us his own honest thoughts, Mr. Edwards finds himself in agreement with the views I have ventured to hold; and perhaps he will kindly favour me with a reply to the query, "How can an amount of energy or momentum *enter* at W or anywhere else?" Let us stick to this one simple point till it has been disposed of, and thus learn to be precise in our statements in order to begin to think clearly.

December 10, 1916. Sesamy.

SCREWING SOLID-DRAWN STEEL TUBES.

To the Editor of Engineering.

Sir,—In using solid-drawn steel tubes for high-pressure pneumatic work (300 to 400 lb. per square inch) I have met with the following difficulty.

As you are aware, this tubing is not turned out to the correct outside diameter for screwing. I have, therefore, been using tubing of $\frac{7}{8}$ in. outside diameter for use with $\frac{1}{4}$-in. fittings, *i.e.*, 0.875 in. instead of 0.844 in., or 0.031 in. in excess of the standard. The result of trying to screw this tube in one cut with the ordinary American adjustable stocks and dies is to tear the threads off in a horrible manner, no matter how much lubricant may be used. A fairly, only fairly, decent thread may be secured by taking from three to five cuts and carefully filing down the tube before each one after the first. Even then the utmost care must be taken as, since the metal appears to become more brittle after each cut, if a very slight hump is left in any place by the file the thread is completely ruined on the next cut. This method, as you can understand, is exceedingly tedious, expensive and exasperating, and I am writing to you in the hope that some of your readers may be able to suggest an alternative. I wonder if it is usual for solid-drawn steel tube to behave in this way? The dies I use cut ordinary wrought-iron tube perfectly.

I should say that the tubes have to be screwed in fairly long lengths, so as to avoid a multiplicity of joints, in out-of-the-way country districts. These and other considerations preclude the use of a lathe to reduce the diameter suitably, and I cannot hear of a hand tool which could be used to trim the ends of the tubes to the correct size for screwing in one cut.

Yours faithfully,
Dublin, December 9, 1916. T. W. K.

WAGON FOR CARRYING WHALES ON THE SOUTH AFRICAN RAILWAYS.

CONSTRUCTED BY THE LEEDS FORGE COMPANY, LIMITED, LEEDS.

IN a preceding issue (see vol. xcix, page 526) we gave an illustrated description of several types of high-capacity wagons constructed for the South African Railways by the Leeds Forge Company, Limited, Leeds, there being among the number a wagon having a capacity of 160,000 lb. for the transport of whales. We illustrate on the present page one of these latter wagons, to which a whale is lashed by chains. As stated in our former article, the wagon is intended to carry whales over a 3 ft. 6 in. line a few miles in length, from the point where they are brought ashore to the factory where they are dealt with for the extraction of oil, &c. The line is very uneven, and the wagon has six-wheeled bogies, so as to keep the axle-loads down to the required limits and to insure the necessary flexibility. The tare weight of the wagon is 74,700 lb. The wagon is 65 ft. long over headstocks and the bogie centres are 53 ft. apart.

REPORT OF THE HARDNESS TESTS RESEARCH COMMITTEE.*

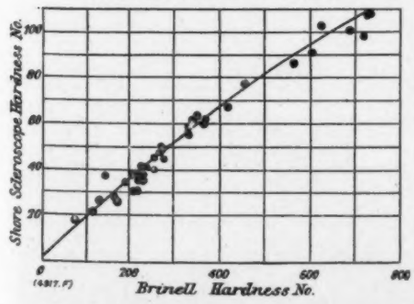
(*Concluded from page 558.*)

GENERAL RESULTS OF THE TESTS.

(1) *Ratio of Brinell Hardness Number to Scleroscope Number.*

The results of these determinations have been plotted in Fig. 7, and are in approximate agreement with the general assumption that the Brinell hardness number divided by 6 is approximately equal to the scleroscope

Fig. 7. COMPARISON OF BRINELL HARDNESS No. AND SCLEROSCOPE No.

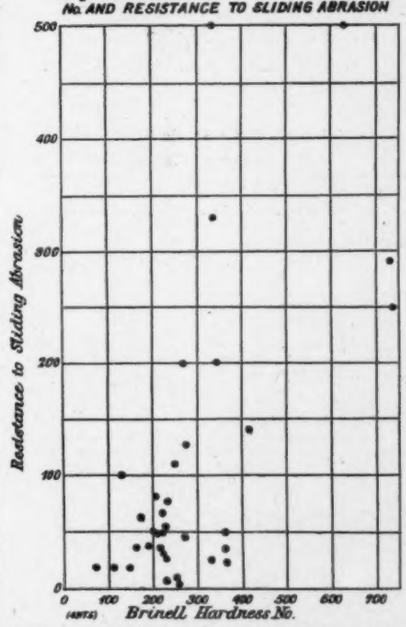


number. According to the evidence of the present tests, the ratio of the Brinell hardness number appears to increase gradually from 5.5 for very soft material to about 8 for materials of over 700 on the Brinell scale. The number of tests on very hard material is, however, hardly sufficient for any definite conclusion to be drawn as to the magnitude of the change in the ratio with increasing hardness, and it is hoped to investigate the relation further in the future.

(2) *The Preservation of the Nature of the Surface during the Progress of the Test.*

From the comparison of the figures in columns 3 and 4 (Table II), page 598, in which are the scleroscope numbers of the surfaces before and after test, it is seen that the characteristic which distinguishes the sliding abrasion test from the rolling abrasion test is that the former does not cause any perceptible hardening of the surface under wear as the test proceeds, that is, the test is not made on deformed material, but on material in the state in which it existed before the test. Slight exceptions to this will be noted in the case of the five manganese steels, in which the scleroscope number for the worn surfaces is on the average 7.5 per cent. greater than on the unworn surfaces. This effect, however, is not surprising considering the marked susceptibility of these steels to hardening under pressure which has been noted in the rolling abrasion tests, in which the hardness numbers were practically doubled by the action of the rolling and also considering the high value of the load, which was adopted due to the considerations stated above.

Fig. 8. COMPARISON OF BRINELL HARDNESS No. AND RESISTANCE TO SLIDING ABRASION



An interesting confirmation of Sir Robert Hadfield's explanation of the high wearing properties of the manganese steels under rolling abrasion, as being due entirely to the hardening of the deformed surface, is seen from the results of Table II, since in the present tests the resistance to sliding abrasion of the manganese steels is fairly low.

In order to obtain a further demonstration of the property of this test, a special set of observations were made on a sample of mild steel (No. 720/2) and a sample of manganese steel (No. 1010/2) by measuring the wear of the (same) surface after successive equal intervals of time. If there were any gradual hardening effect on the surface, this would reveal itself in the gradual reduction of the rate of wear with time. As will be seen from the results given in Table III,, page 598, no action of this kind can be detected.

(3) *The Relation between the Resistance to Sliding Abrasion and the Brinell Hardness Number.*

The ratio of the numbers expressing these characteristics are given in column 8 of Table II, and the results are plotted in Fig. 8.

In order to express in a concise form the extreme variations in resistance to wear corresponding to any given Brinell hardness number, which have been found in the miscellaneous selection of materials tested for the present investigation, the figures given in Table IV have been abstracted from Table II. These give the maximum and minimum values of the resistance to sliding abrasion for materials whose Brinell hardness number is approximately the same.

Closer examination will show that it is the special steels which are responsible for the enormous variation in resistance to sliding abrasion which is given in Table IV, and that in the case of ordinary carbon steels the fluctuation is much less. As regards the latter steels, it may be said that high Brinell hardness number will generally indicate a high resistance to sliding abrasion, but there are exceptions to this rule.

As regards the general results of the investigation, it is clear that the Brinell hardness numbers of a miscellaneous selection of steel are not a safe guide in predicting their relative resistances to wear. This result is in general agreement with those obtained by Robin, Nusbaumer and Saniter, with other methods which have been referred to in the president's memorandum (Appendix I).

APPENDIX I.

MEMORANDUM ON TESTS OF HARDNESS AND RESISTANCE TO WEAR.

By W. CAWTHORNE UNWIN, LL.D., F.R.S.

Hardness is a property of materials very important in many cases, but as to which there is not an agreed definition, nor is any one method of measurement generally adopted. Most commonly, by *hardness* is meant the resistance a material opposes to penetration by another body.

The earliest scale of hardness is that proposed by the mineralogist Moh. He selected 10 natural substances, arranged so that each would scratch the substance next below it in order, and be scratched by that next above it. On this scale talc had a hardness 1, and diamond a hardness 10. A copper coin had a hardness 3, ductile iron a hardness 4.5, a file a hardness 6.5. It is a defect of the Moh scale that materials selected by him vary somewhat in hardness in different specimens.

*Professor T. Turner's Scratch Test.**—A balanced lever capable of moving vertically on a knife-edge and of being rotated is graduated and provided with a sliding weight. The free end carries a diamond point which can be moved over the surface of the material to be tested. The graduations are such that a movement of the sliding weight over one scale division corresponds to 10, 20, 30, or 40 grammes at the diamond point, according to the sliding weight used. The surface of the specimen is smoothed and polished with flour emery and oil. The weight in grammes at the diamond point which produces a decided scratch is taken as the hardness number. There is some skill in determining this. Turner suggests making several scratches with diminishing weights, and taking for the hardness number the mean between the smallest weight which produces a quite definite and visible scratch, and the greatest weight which does not

* Paper read before the Institution of Mechanical Engineers, November 17, 1916.

* Proceedings, Birmingham Philosophical Society, vol. v, part 2, 1886.

TABLE II.

Test No.	Marks.	Condition of Material.	Analysis. C.	Si.	Mn.	S.	P.	Cr.	Ni.	1 Brinell Test. Unworn surface.	2 Brinell Test. Worn surface.	3 Scleroscope Test. Unworn surface.	4 Scleroscope Test. Worn surface.	5 Sliding Abrasion Test. Thickness removed mils. per 1,000 ft. slip.	6 Sliding Abrasion Test. Resistance to sliding abrasion.	7 Ratio. Brinell Number / Scl. No.	8 Ratio. Brinell No./Resistance to sliding abrasion.
1	6	Hardened in oil at 850 deg. C.; tempered in gas muffle at 600 deg. C.	0.70	—	—	—	—	2.0	2.5	420	420	67	68	0.7	140	6.3	3.0
2	1010/2	Manganese steel as forged	1.36	0.36	13.10	—	—	—	—	277	284	44	46	2.2	45	6.3	6.2
3	1010/1	Do quenched at 950 deg. C. in water	1.36	0.36	13.10	—	—	—	—	219	230	34	39	2.1	48	6.4	4.6
4	1068A	Do. water-toughened ..	1.26	0.11	9.22	—	—	—	—	203	—	30	31	2.0	50	6.8	4.1
5	1010	Do. do. ..	1.18	0.14	12.29	—	—	—	—	206	—	30	32	2.1	48	6.9	4.3
6	2055	Do. do. ..	1.48	0.25	15.23	—	—	—	—	228	—	34	37	1.0	53	6.7	4.3
7	A	Carbon steel as rolled ..	0.52	0.10	1.26	0.05	0.09	—	—	234	237	41	41	1.3	77	5.7	3.0
8	8	Do. do. ..	0.50	0.19	0.94	0.07	0.07	—	—	228	228	36	35	3.9	26	6.3	8.8
9	11	Do. do. ..	0.60	0.15	0.93	0.04	0.10	—	—	252	248	40	39	0.9	110	6.3	2.3
10	3123C	Do. do. ..	0.75	0.20	0.84	0.04	0.05	—	—	273	282	50	50	0.8	125	5.5	2.2
11	2217	Do. oil-toughened ..	1.62	0.15	0.29	0.02	0.02	—	—	346	349	62	61	0.5	200	5.6	1.7
12	1772A	Do. do. ..	0.43	0.14	1.44	0.06	0.06	—	—	216	—	37	37	2.9	35	5.8	6.2
13	6B	Do. do. ..	0.44	0.48	1.01	0.06	0.06	—	—	222	—	37	38	3.2	31	6.0	7.2
14	2250/958	Do. as rolled	0.65	0.13	0.60	0.02	0.03	—	—	235	—	41	42	1.1	91	5.7	2.6
15	2250/955	Do. toughened	0.65	0.13	0.60	0.02	0.03	—	—	337	—	61	61	0.3	330	5.5	1.0
16	2250/956	Do. do. ..	0.65	0.13	0.60	0.02	0.03	—	—	330	—	58	58	0.2	500	5.7	0.7
17	720/1	Do. mild steel	0.21	0.02	0.46	0.05	0.06	—	—	115	116	21	24	5.3	19	5.5	6.0
18	704/1	Do. mild steel mechanically hardened to 35 tons per square inch	0.04	0.05	0.41	0.04	0.07	—	—	149	144	37	37	5.5	18	4.0	8.3
19	A1629	Rail steel, as rolled ..	0.45	0.11	0.97	0.05	0.05	—	—	190	—	34	36	2.65	38	5.6	5.0
20	B1631	Do. do. ..	0.52	0.15	0.75	0.01	0.03	—	—	206	—	37	38	1.27	80	5.6	2.6
21	1908D	Self-hardening steel, air-hardened	0.60	—	—	—	—	3.5	W 16.2	627	—	103	103	0.2	500	6.1	1.3
22	1109D	Special steel, water-toughened	0.60	0.62	5.0	0.05	0.06	—	Ni. 15.0	175	—	26	29	1.6	63	6.7	2.8
23	3137D	Do. oil-toughened ..	0.66	0.15	0.23	0.02	0.03	2.5	2.8	364	—	60	61	2.8	36	6.1	10.1
24	1795E	Do. annealed	0.35	0.08	0.66	0.05	0.03	1.75	3.7	255	—	45	46	9.6 & 26.6	10 to 4	5.7	25 to 64
25	2297	Do.	0.57	0.20	0.76	0.05	0.06	1	—	271	—	47	47	0.5	200	5.8	1.4
26	3109	Do.	0.33	0.07	1.21	0.05	0.06	1.25	—	226	—	41	41	1.5	67	5.5	3.4
27	1795Q	Do.	0.20	0.04	0.38	0.05	0.05	2	4	366	—	61	63	2.0 & 4.6	50 to 22	6.0	7.3 to 16.6
28	3121	Do.	0.31	0.05	1.18	0.05	0.08	1	3	332	—	55	56	4.2	24	6.0	13.8
29	3102	Do.	0.18	0.03	0.48	0.03	0.03	0.5	2.5	165	—	28	29	2.8	36	5.9	4.6
30	68	Gauge steel, hardened ..	1.02	0.31	0.45	0.02	0.03	1.43	0.03	720–740*	—	107	106	0.35	290	6.8	2.5
31	4789	Do. do.	0.86	0.18	1.34	0.02	0.03	0.05	—	675–695*	—	100	101	0.1	1,000	6.8	0.7
32	B.D.	Do. do.	0.97	0.12	0.26	0.01	0.02	0.14	W 1.38 / V 0.34	725–750*	—	108	112	0.4	250	6.8	3.0
33	C.	Do. case hardened ..	0.28	0.05	0.91	0.08	0.06	0.04	—	—	—	110	111	0.2	500	—	—
34	F.	Do. unhardened	0.72	0.12	0.22	0.01	0.07	4.16	W – 12.69 / V – 0.34	228	—	37	40	14.7	7	6.2	32.6
35	719	Admiralty bronze.								75	82	17	26	4.9	20	4.4	3.8
36	708	Phosphor bronze								131	137	26	29	1.0	100	5.0	1.3

* Values approximate owing to flattening of ball.

TABLE III.

Material.	No. of Revolutions.	Wear in mils. per 1,000 ft. slip.	Resistance to sliding abrasion.
Mild Steel, No. 720/2.	0–10,000	5.5	18
	10,000–20,000	5.8	17
	20,000–30,000	5.8	17
	30,000–40,000	6.1	16
Manganese Steel, No. 1010/2.	0–10,000	2.0	50
	10,000–20,000	2.0	50
	20,000–30,000	2.0	50
	30,000–40,000	2.2	45

TABLE IV.

Brinell No.	High Resistance to Sliding Abrasion. Test No.	High Resistance to Sliding Abrasion. Resistance to Abrasion.	Low Resistance to Sliding Abrasion. Test No.	Low Resistance to Sliding Abrasion. Resistance to Abrasion.
165–175 ...	22 (175)	63	29 (165)	36
190–206 ...	20 (206)	80	19 (190)	38
226–228 ...	26 (226)	67	34 (228)	7
228–235 ...	14 (235)	91	8 (228)	26
255–271 ...	25 (271)	200	24 (255)	4 to 10
330–332 ...	16 (330)	500	28 (332)	24
306–364 ...	11 (346)	200	23 (364)	36

produce a visible scratch. Turner found the following hardness numbers:—Lead, 1; annealed copper, 8; softest iron, 15; mild steel, 21; tyre steel, 20–24; hard cast scrap iron, 36; hardest cast iron, 72.

To make the test more definite, Martens defined the hardness number as the weight in grammes which would produce a scratch 0.01 mm. in width. Several scratches are made and the loads and widths plotted. With a diamond point ground to an angle of 90 deg. Martens obtained the following hardness numbers:—Lead, 17; copper, 34–40; soft steel, 71–77; hard steel, 138–141.

Indentation Methods.

Various investigators have used an indentation test for determining hardness, and such a test is specially suitable for ductile metals. The indenting tool has been a knife-edge, cone, or pyramidal point. The weight causing a given depth of indentation, or the reciprocal of the depth of indentation with a given weight, have been taken as the measure of hardness.

Foeppl placed two cylinders of the material to be tested at right angles and pressed them together in a testing machine. The pressure per unit of flattened surface is taken as the measure of hardness. The method is good, but the preparation of specimens is rather costly.

The author* used as an indenting tool a square bar of hardened tool steel (Fig. 9) with edges accurately ground. The material tested was formed into a bar $2 \times \frac{1}{4} \times \frac{1}{4}$ in. The tool was pressed into the specimen in a testing machine, and the load P in tons and corresponding depth of indentation i in inches were noted. Then $C = P/i$ was taken as the hardness number. The hardness number varied from 195 to 256 for different steel rails having 0.329 to 0.415 per cent. of carbon. It was found that the ratio (tensile strength)/(hardness number) was nearly constant. For the series of (13) rail steels its mean value was 0.181 (ton and inch units).

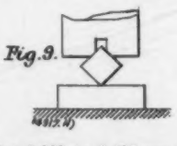


Fig. 9.

The Brinell Hardness Test.—In 1900 Mr. J. A. Brinell* described an indentation test for hardness, the indenting tool being a spherical ball. Some convenient forms of apparatus for applying this test have been devised by Martens and others, and it is now very generally used. Let P be the pressure in kilograms, D the diameter of the ball, d the diameter and h the depth of the indentation, all in millimetres. Then

$$h = \tfrac{1}{2}\,(D - \sqrt{D^2 - d^2})\ \text{millimetre},$$

and the area of the spherical surface of the indentation is

$$A = \pi\, D\, h = 1.571\, D\,(D - \sqrt{D^2 - d^2})\ \text{square millimetre.}$$

Then Brinell takes the hardness number to be $H = P/A$.

To determine H, the load P and the corresponding value of either h or d must be observed. It is simpler to measure h, but it has been found generally more convenient to measure d with a micrometer microscope. More recently a glass slide with two inclined engraved lines has been used. For strictly comparable results fixed values must be taken for D and P. For steel it is usual to take P = 3,000 kg. and D = 10 mm. For softer materials Brinell suggests that P should be taken = 500 kg., and gives a table of the corresponding values of d with 3,000 and 500 kg.

Grard, in a paper before the International Association for Testing Materials, at New York, discussed some of the sources of error in the Brinell test. Ludwig suggested the substitution of a cone for the ball.

Brinell noticed a close correspondence between the hardness number and the tensile strength of a material. For Fagersta steel the ratio of tensile strength to hardness number was very approximately 0.346 (kilogram and millimetre units). Dillner found the ratio for hardness numbers below 175 to be 0.354 and for those above 0.324. Charpy in the same cases found the ratios 0.351 and 0.336.

The Shore scleroscope is a rebound instrument for testing hardness, patented by an American engineer. A full description of the apparatus and its applications is found in a pamphlet obtained from the Coats Machine Tool Company, Caxton House, London, S.W. The essential part is a diamond-faced hammer or tup, weighing about 40 grains, which is allowed to drop on the material to be tested from a fixed height, and the height of rebound is observed against a graduated scale. Ingenious arrangements are provided for lifting and releasing the hammer by air pressure from a bulb. The indenting part of the hammer is convex, and it appears to be essential that a permanent indentation should be made in the material tested. The test, therefore, appears to be in fact an indentation test, the rebound being diminished by the amount of work expended in indentation. The area of the indenting point is stated to be $\frac{1}{1500}$ of a square inch. A magnifier hammer with larger point is used for very soft materials. The surfaces tested are smoothed but not polished. The scale is graduated into 140 equal divisions and medium hard hardened steel gives a hardness number 100. It is stated that the Brinell hardness number divided by 6 agrees approximately with the Shore scleroscope number.

* Proceedings, Institution of Civil Engineers, vol. cxxix, 1897.

* Sur les epreuves a bille en acier. Communications devant le Congrès International des Methodes d'Essai des Materiaux, Tome II, page 81. Paris, 1901. Materialienkunde, IX, 318; X, 54; XI, 6.

It appears from the relation of the tensile strength and indentation hardness that the latter is simply, at any rate for steels, a strength test. This must have been a surprise to those seeking a test for hardness, who no doubt regarded it as a separate property of materials, although of course the fact that hardness and strength both increase with the percentage of carbon was well known. The rebound test of balls for ball bearings appears to be a test of elasticity not of hardness, the pressure not being great enough to cause permanent deformation.

RESISTANCE TO WEAR.

In a large number of cases hardness in a material is desired on the assumption that the harder a material is the greater will be its resistance to abrasion and wear. But the point requires separate investigation. It will be found that hardness as determined by the methods described above and resistance to abrasion or wear are not in any exact relation.

Various methods of testing resistance to wear or abrasion have been tried. Bottone used a soft iron disc rotating at a constant speed and pressed with a constant force against the material tested. The time required to produce a cut of a definite depth was taken as the measure of resistance (*Chemical News*, vol. xxvi, page 215, 1873). M. Felix Robin (Iron and Steel Institute, 1910) used cylindrical specimens, 50 mm. in diameter, rubbed under a definite pressure on papers covered with abrasive powders. M. Derihon devised a machine in which a lever presses the specimen on the circumference of a polished wheel turning at high speed in an oil bath. The speed of the wheel was 3,200 r.p.m. and each test was continued for 2,000,000 turns. The wear was measured in thousandths of a millimetre. Professor M. Gary (Mitt. aus dem Kön. Materialprufungsamt, Berlin, 1904, 103) has used the abrading power of a sandblast to determine resistance to wear, chiefly of natural stones, artificial minerals and timber.

MR. SANITER'S COMPARISON OF DIFFERENT TESTS OF HARDNESS AND WEAR.

Mr. E. H. Saniter, of Rotherham, in a paper read at the New York Congress of the International Association for Testing Materials, 1912, gave the results of a very interesting investigation of the results of determining hardness and wear of the same materials by different methods. He used two methods of determining hardness, the Brinell test and the Shore sclerometer test. For the steels examined both methods place the steels in the same order with one exception. But the ratio of the Brinell number to the Shore number shows some variation.

Mechanical wear, in Mr. Saniter's view, implies the removal of a portion of the material in small particles by friction. This may occur (*a*) by pure abrasion; (*b*) by lubricated sliding friction; (*c*) by dry rolling friction. He points out that vibration enormously increases the amount of wear, and that it is necessary to check the effect of vibration of the testing machines by testing a standard material at frequent intervals.

(*a*) *Pure Abrasion.*—M. Robin tested wear by using emery and other abrasive papers, and at the same time determined the Brinell hardness number. It appeared that there was no relation between the Brinell hardness number and the resistance to wear tested by M. Robin's method. Yet that method seems a reasonable one for determining the resistance to abrasion.

(*b*) *Lubricated Sliding Friction* has been investigated by E. Nusbaumer, using the apparatus of M. Derihon, which consists of a hard steel disc running in oil on the edge of which a specimen is pressed. The Brinell hardness number was also determined, but it has no relation to the resistance to wear found by the Derihon test. Yet it seems that the latter should give correct results as to wear by sliding friction.

(*c*) *Dry Rolling Friction* was tested by a wear machine designed by Mr. Saniter. A revolving test piece drives by friction on its top side the inner ring of a loaded ball bearing. The results on 0.7 per cent. carbon steel subjected to various heat treatments show a general relation to the corresponding Brinell number. There are, however, two exceptions. In another series of tests of different carbon steels treated alike there is also a distinct relation, with one glaring exception. In a third series of tests on alloy steels the relation between the Brinell number and the Saniter test of wear entirely breaks down.

But the reliability of this wear test is emphasised by the test on Hadfield's manganese steel, which gives, with a low Brinell number, the best wear number of all the steels tested. The excellent wearing properties of manganese steel rails is well known.

The importance to the committee of the results in Mr. Saniter's interesting paper is this. It is probable that the firm who suggested to the Institution an investigation of a hardness test for case-hardened bearings and hard cast iron for cylinders really were seeking a test for resistance to wear and tear, and confused this with a test of hardness as generally understood.

APPENDIX II.

MEMORANDUM ON HARDNESS.

By SIR ROBERT A. HADFIELD, D.Sc., D.Met., F.R.S.

1. When an inquiry is made as to what is meant by hardness, it is found this is a somewhat indefinite and vague term. When "hardness" is spoken of, no more definite statement is intended than if, for instance, the term "strength" is being discussed.

2. If anyone were asked to measure the strength of a certain specimen, he would immediately ask "under what conditions?" He would then be told that what was required was, for instance, what pressure or tension it would stand without extending (or being compressed) more than 10 per cent.; or what load before it fractured?

3. Hardness is no more definite than this. Hardness, in other words, is not a specific property of a material. To make it specific it must be hedged round with definite instructions as to the limit to which the material must be deformed. A definite figure cannot be assigned for any property of a material unless this property is specific one.

4. The writer's conception of hardness is simply "resistance to deformation." Now the resistance to deformation of any material depends on how much it is deformed—as a rule, the more it is deformed the greater is the load required (for some viscous materials, such as pitch, the deformation proceeds continuously under a constant small load). Further, the rate of increase of load with deformation varies in different materials.

5. It is useless, therefore, to fix an arbitrary amount of deformation and measure the load, for of two materials A and B, A may require less load than B to deform it 5 per cent., but B may require less load than A to deform it 50 per cent. Also, brittle materials will not deform at all.

6. The efforts to establish an academic idea of hardness are, therefore, limited to the resistance offered by a material free to flow, up to the point when it is just permanently deformed, which in the case of brittle materials, of course, means fractured. In elastic material this academic definition of hardness is nothing more than the "yield-point." To measure the hardness one has, therefore, only to measure the "yield-point."

7. This definite and specific property seems to be the real "fundamental hardness," and indeed the whole hardness of brittle materials.

8. According to this criterion manganese steel is of a soft nature. Its yield-point is low, a very small load producing permanent deformation. From this standpoint manganese steel, unless its character is altered by deformation, is really soft, yet in the ordinary acceptance of the term this material is considered very hard. Why is this? The explanation is that the ordinary term involves a loose conception of more or less (no definite amount) deformation, and the "hardness" is that of the more or less deformed material. Manganese steel is an extremely hard-wearing material, in spite of its natural softness, because the act of abrasion deforms the material locally, its resistance to further deformation increasing enormously thereby, and the material actually abraded off is not manganese steel in its natural state, but is the quite different material, *deformed manganese steel*. Manganese steel is soft—deformed manganese steel is hard. In a pulled tensile bar over 500 ball number has been obtained, and yet the material is just as non-magnetic as before, showing this physical change has taken place without interfering with its peculiar non-magnetic qualities. Deformed manganese steel has its own specific properties, quite distinct from manganese steel in its natural state or manganese steel subjected to other heat treatment than water toughening. Somewhat similar remarks apply to bronzes and other materials.

9. This is really the crux of the difficulty in trying to assign a value to the practical term loosely known as hardness. It is not sufficient, however, in all cases to measure the resistance of the material to deformation at the point of rupture. In the first place, it is not possible to deform any specimen of material so that at all points where fracture occurs the amount of deformation is uniform. There seems no way of measuring the resistance to deformation (*i.e.*, the true "hardness") of deformed materials except in an approximate manner. In the second place, the action of deformation, in the practical use to which the material is applied, is to deform some parts more than others, in no regular and definite manner.

In scratch tests a comparison is made between the breaking stress of two substances; as the pressure is being applied, stress is applied equally on the two materials, and they deform accordingly, until one of them reaches its limit of deformation, breaks off, and is then said to be "scratched" by the other. The other is "harder" by virtue of the fact that its breaking stress is greater, and the method places materials in a series of ascending "hardness," that is, ascending "breaking stress." Some idea of the relative "hardness" of materials, for example, in Moh's scale, might therefore be determined (only approximately as mentioned above—due to unequal strain and difficulties due to cleavage) by tensile or shear tests, measuring the breaking stress per unit area of the fracture.

Scratch tests, therefore, while probably enabling a definite *comparison* to be made of the true deformation hardness, do not give a numerical value.

10. Now all this applies only to ductile materials. Brittle materials which do not deform clearly cannot have this complication of deformation hardness. In these cases, therefore, a practical measurement of hardness, which in reality is the stress at the yield-point, is possible.

There is here, however, a still further complication. Viscous materials, like pitch, while requiring in the ordinary way a definite stress to produce deformation and rupture, if sufficient time is allowed will deform under the slightest stress. The definition of natural hardness should, therefore, include an arbitrary time element, and this is a matter of practical arrangement. The time rate would theoretically be infinitely slow, but this would destroy the practical value of the definition, as it would make pitch almost infinitely soft, like a limpid fluid, while to all practical intents it is rather hard. The time rate of loading must, therefore, be within the ordinary limits of practical testing. It might be stated that many of the "elastic" materials behave somewhat like pitch.

11. It will be readily understood from the above what relation the results obtained from current methods of testing hardness have to the true hardness of materials. Each of these methods in the case of ductile materials deforms the material in its own particular fashion. It deforms one part of the material more than another, and the relative degrees of deformation are quite different according to the method employed. For example, in abrasion or scratch methods some portion of the material is completely detached, that is, deformed to the point of rupture: in indentation tests the material is generally not broken; in each case the remaining portions are deformed in varying degrees from nil to the maximum, and not in equal gradients. How, therefore, can it be expected that these methods should agree among themselves, or that the results should represent some specific property of the material? Further, with indentation tests, even with tests by the same method, on different materials the same defect exists. How, therefore, can any of these methods give a true numerical relation between the hardness of two materials, so as to say, for instance, that one material is twice as hard as another?

12. Summing up, the situation seems to be:—

(*a*) Hardness as generally understood, is a loose term, not representing any specific property, but "resistance to deformation."

(*b*) The greater resistance in general of deformed materials to deformation (or deformation hardness) over that required to produce the first permanent deformation in the same undeformed material (or natural hardness) is involved to an indefinite extent in this term.

(*c*) No single value can therefore be assigned to the hardness of the material in this general sense. It can only be expressed by a complete stress-strain curve.

(*d*) The "natural hardness" can be measured, and is the "yield-point stress." Even this is subject to disability in the case of viscous materials like pitch.

(*e*) There seems to be no satisfactory method of determining "deformation hardness"—that is, the resistance to deformation of material deformed practically to its fullest extent. Scratch methods enable comparisons to be made of this more or less definite property, but do not give a numerical value.

(*f*) Other methods professing to measure hardness measure the resistance of material deformed to varying amounts in different parts, and cannot therefore be expected either to agree among themselves or to give a true numerical value for the hardness.

(*g*) Brittle materials in which little or no deformation is possible are not subject to this complication of deformation hardness. On the other hand, they cannot be indented without fracture (cracking), and the utility of indentation methods is destroyed in their case.

APPENDIX III.

DEFINITION OF HARDNESS.

By A. E. H. TUTTON, D.Sc., F.R.S.

The hardness of a solid substance may be defined as the resistance offered by a smooth surface of the substance to abrasion. It is measured by the capability of the substance being just abraded or scratched by contact with a sharp fragment of another substance of slightly greater hardness, and of which the precise degree of hardness is known with reference to a conventional scale. Particles of the softer substance are torn away by the harder, their cohesion being overcome. Hence, hardness is intimately connected with cohesion. If the solid substance is crystallised, the hardness varies slightly with the direction within the crystal, as cohesion in a crystal is in general dissimilar in different directions; thus hardness is always lower along a direction of cleavage than along the direction perpendicular thereto. For cleavage planes are planes of points of the crystal space-lattice which are most densely strewn with points, and in which cohesion is, therefore, a maximum, while successive parallel planes of points (all parallel to the plane of cleavage) are the most widely separated from each other, the points being farthest apart in the direction at right angles to these planes; the cohesion is, therefore, minimum perpendicular to the plane of cleavage. The particles are, consequently, more readily torn off from a cleavage face than from any other face of a crystal. Moreover, high specific gravity (density) is generally accompanied by great hardness. For (considering the case of the perfect solid—a crystal), the points of the space-lattice being the closer together the denser the substance, greater difficulty is naturally experienced in overcoming their cohesion, in accordance with the usual laws governing the attractive forces between particles.

PROFITS IN AUSTRIA.—The Prague Iron Industry Company paid 38 per cent. for the year ended June 30, 1916, against 24 per cent. for last year and 8 per cent. for the preceding year; the dividend for the year now reported upon is the same as that paid for the year 1912–13, the net profits being respectively 15,350,000 kronen and 15,100,000 kronen. With the exception of a slight decrease in the production of coal, other figures show a material increase as compared with 1914–15, viz.: pig-iron about 100 per cent., iron ore and half-finished products 60 per cent., and finished rolled goods 50 per cent.; the latter output exceeds the record figure of 1912–13 by 50 per cent., the other commodities mentioned being only slightly behind those of that year. The number of hands employed, June 30, 1916, amounted to 14,220, against 12,880 the previous year. The firm is engaged to its fullest capacity until far into 1917.

A METHOD OF DETERMINING THE DENSITY OF FLUE GASES.*

By Jas. Alex. Smith, Past President.

Engineers, whether power, metallurgical or manufacturing, can always ascertain the density of the gases within their province, either by chemical analysis or precision weighing. But it is not always essential to know the chemical composition; or the composition may be deducible with sufficient accuracy if the density is known. Then methods of a simpler or more direct character have a use, particularly when it is desired to study cause and effect concurrently, and without any appreciable intervening interval during which the cause might vary.

The purpose of this paper is to describe a mode of determining gas density by gauge reading. So far as the writer is aware, the method is new.

General Principles.—The basic theorem is that the densities of gases and their pressures per unit area of base are directly proportional when the gas columns are of equal height. Hence, if a column of air in a vertical tube of known height is displaced by a given gas, the barometric and thermometric conditions remaining constant, the densities are in the simple ratio

$$D = \frac{P \pm P'}{P} \quad . \quad . \quad . \quad . \quad (1)$$

when

D = Density of the given gas referred to air taken as unity,
P = Known air pressure due to column height, and
P′ = Difference (±) of pressure due to gaseous displacement.

Pressure Measurement.—Assume that an accuracy within 1 per cent. of the total air pressure due to the vertical or column height is required; in other words, that a pressure due to the air in a column the one-hundredth of the height of the column in the given case must be evaluated. This order of minuteness of magnitude at once contra-indicates mechanism subject to friction, and indicates the use of "frictionless" liquid gauges.

Postulating that, without the introduction of undesirable complications, 0.02 in. is the smallest significant difference of level of such a gauge, then the relation of that minimum gauge space to the minimum correlated gas-tube height (h) is given by the equation

$$h = .02 \text{ in.} \times 100\,x \quad . \quad . \quad . \quad (2)$$

when x is the specific gravity of the gauge-liquid referred to *air* as unity. Therefore water, which is about 772 times heavier than air, if used in a simple siphon gauge, and under the conditions postulated, requires a complementary gas-tube not less than 0.02 in. × 100 × 772 = 1,544 in. = about 130 ft. in height. Conversely, if the height (h) in inches be given, then the maximum specific gravity of the possible gauge-liquid (air, as before, being taken as unity) is determined by the formula

$$x = \frac{h}{2} \quad . \quad . \quad . \quad . \quad (3)$$

Any convenient value may be assigned to h. Let, then, the vertical height of the gas column be 100 in. Then x = specific gravity 50. That is, for such a tube height, a liquid is indicated not more than 50 times heavier than air, or, $\frac{772}{50} = 15.44$ times lighter than water.

No such light liquid is known; but its equivalent may be attained if two immiscible liquids are caused to partially equilibrate each other in such a manner that the *difference* (which may be made as small as desired) of the specific gravities becomes the measure of the equivalent specific gravity of the liquid system as a whole.

A gauge on the differential principle, capable of readily dealing with gas pressures of the small magnitude in question, has already been described by the author in the "Proceedings" for November, 1909, vol. x, page 155, under the title, "A Simple, Sensitive, Two-Liquid Differential Gauge for Measuring Small Pressures."†

Gas Tube.—The gas tube is very simple. In the example illustrated it consists of a piece of ¾-in. wrought-iron gas-barrel, A, 100 in. in height. At the bottom two stopcocks, B, C, permit alternative connection to a gas-source or to a gauge, E. To check diffusion the passage through the latter cock should be reduced to a pin-hole. At the top a third cock, D, opening into the air, permits the tube to be gas-flushed and filled, and when the main passage is closed continues the connection by a minute by-pass large enough to preclude any possible barometric difference of pressure between the gas inside and the air outside the tube, yet so small that diffusion is negligibly slow. The surface of the liquid in the gauge cistern and the bottom of the gas tube must be approximately at the same level.

Calibration.—If the gauge constants are unknown, a simple, comprehensive calibration covering all the factors can be effected thus: All parts being filled with air, adjust the gauge to zero. Then displace the air in the tube with any easily generated or procured gas of known density, for instance CO_2, the specific gravity of which is 1.524. Then the pressure upon unit of base of 100 in. vertical of CO_2 is equal to the pressure of 100 × 1.524 = 152.4 in. of air. Therefore, the consequent liquid displacement due to the displacement of the air by gas is equivalent to that which would be caused by an air pressure of 152.4 − 100.0 = 52.4 in. The scale can be graduated or interpreted accordingly.

Corrections.—When relativity only is required, corrections may be dispensed with. The case of the immediate effect of draught volume variation upon chimney-gas density is an example.

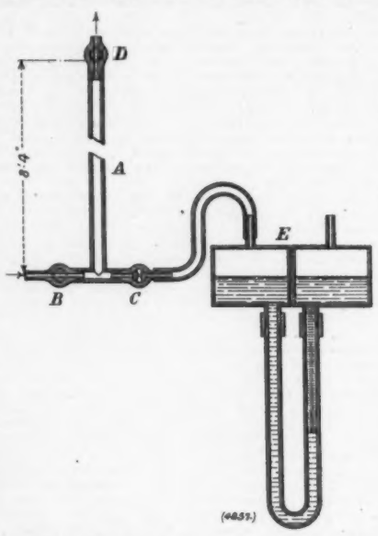
But if absolute readings are required, and if the barometric and thermometric conditions differ from those which may have been assigned in respect to P (formula 1), and upon which the value of the gauge divisions is computed, then a corrected value P″ must be substituted for observed P′ in formula (1); then

$$P'' = \frac{(461 + t)\,29.92 \times P'}{461 \times b} = \frac{(461 + t) \times P'}{15.41 \times b} \quad . \quad (4)$$

when

t = Observed temperature on Fahrenheit scale,
b = Observed barometric pressure in inches,
P′ = Observed pressure due to gas displacement, and
P″ = Corrected value of observed displacement pressure.

Strictly, a further correction should be made to compensate for the variation in the gas system volume,



A—Gas tube. B—Inlet gas cock. C—Gauge cock. D—Outlet gas cock. E—Differential gauge.

Note.—The barometric equalising vent (at D) is not shown. It consists of a piece of clockmaker's "bushing wire," 1 in. long and $\frac{1}{16}$-in. bore.

due to the movement of the liquid in the gauge. Usually, however, this amount is so small that it may be neglected in practice.

Scales.—The actual graduations may be in any convenient term, i.e., density or specific gravity, percentages, or direct evaluations of the major object of the test.

Variants.—(i) The mode is equally applicable in the case of density change due to chemical reaction other than combustion.

(ii) In the case of inconveniently high tubes, all adjustments may be brought within operative reach by constructing the tube as an inverted ∩, providing that the minute equalising vent must then be placed at the vertex, and must remain permanently open.

(iii) A gas tube within a chimney and extending to its full height affords a means of ascertaining the density of the chimney gases at the *mean* temperature within the whole stack. From this may be deduced the potential ascensional power of the gases, a result not given by the ordinary draught gauges, which show the utilised value only.

(iv) Obviously portability can be attained by constructing the tube in screwed sections.

(v) Photographic continuous records can be attained by the use of any of the well-known devices. This implies a constant passage of gas, therefore precautions must be taken against the vitiation of the results by the introduction of extraneous pressure head, either by periodically cutting off the gas supply, or by making the inlet very small in comparison with a relatively large outlet permanently open. Necessarily there will be a lag in the records in respect to time.

* Paper read before the Victorian Institute of Engineers, July 6, 1916.

† Also reprinted in Engineering, vol. xc, page 144.

Engineers and Civil Service Appointments in Germany.—The Verein Deutscher Ingenieure have addressed to the German Chancellor a long and reasoned protest against the present system of selecting candidates for the higher positions in the German civil service. They state that scientific and technical acquirements are completely ignored, a legal training being the prime essential insisted on in every administrative post. The protest declares that civil servants have now to deal with problems which require the type of mental equipment which is provided by the technical high schools, and there would, it is stated, be no difficulty in giving pupils at these as much knowledge of law and administration as is needed in practice.

FOREIGN ENGINEERING PROJECTS.

We give below a few data on several foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Republic of Colombia.—The *Diaria Oficial*, Bogotá, publishes the text of a resolution authorising the municipal council of Remedios, department of Antioquia, to raise a loan of 26,800 pesos gold (5,360*l.*) to be devoted to electric lighting and aqueduct works in the Remedios district. The *Diario* also publishes a resolution authorising the municipal council of San Jerónimo, department of Antioquia, to raise a loan of 4,000 pesos of gold (800*l.*) for the installation of an electric power plant. A further resolution, published in the *Diario*, grants permission to the municipal council of Quibdó, capital of the Chocó Intendency, to raise a loan of 10,000 pesos gold (2,000*l.*) for carrying out electric lighting works.

Peru.—The following notes on markets for machinery and machine tools in Peru, taken from a report to his Government by a special agent of the United States Department of Commerce, may be of interest to British manufacturers in reference to trade after the war:—The principal demand for machinery and machine tools in Peru arises from the cotton mills and mines, but there is also a demand to some extent from the smaller industries mentioned below. In view of the development of the mining industry (mainly copper, gold, silver, coal and petroleum), there is every reason to expect an increased demand for mining machinery in the future. Openings exist for the sale of prospecting tools and small engineering supplies, stocks of which are carried by local importers and dealers. Peru also offers a market for hydraulic machinery and for pumping plant for irrigation and other purposes. In time, as the small mines develop, there is likely to be a more valuable market for heavy mining tools and machinery. At present these mines use hand tools almost exclusively, but the more prosperous of them will sooner or later instal compressed air or electric drills, dynamos, and other classes of machinery belonging to mining and concentrating plants, and the necessary repair shops will require machine tools. In the meantime, the small market should not be neglected. It is questionable, however, whether it would pay to work it through the medium of salesmen. The various plants are widely separated, and long residence in the country is required in order to learn the peculiarities of the market and the reliability of possible customers. Moreover, it is very hard to sell for cash. Recent years have seen a considerable increase in industrial activity in Peru. On the whole, the textile industries have been the most successful, since cotton and wool are produced locally in quantities and qualities sufficient to ensure profitable results. The only other industries that have attained much importance include the manufacture of cottonseed oil, soap and cocaine. The cotton mills in Peru manufacture principally sailcloth, filter-press cloth, towels, and some other heavy goods. The total number of looms in operation is 1,015, and the annual production is about 15,000,000 yards. The development of this industry will create a fairly good opening for cotton mill machinery. The woollen industry is also expected to expand. The extension of cotton cultivation during recent years has caused some development in the cotton-seed oil industry. There are six or seven soap and candle-making factories in Lima and there are 20 others for the extraction of alkaloid from the coca shrub. Other Peruvian industries are the manufacture of hats, cigarettes, matches, leather, shoes, paper, glass, furniture, lumber, and beverages and foodstuffs. The probable market for the smaller kinds of industrial machinery is very limited, and it would hardly pay any single manufacturer to send out a salesman to sell his own product solely. The report referred to, which also discusses the equipment of light, power and tramway companies in Peru, and the machinery used in the sugar and mining industries, may be consulted by British firms interested at the Commercial Intelligence. With reference to the foregoing, regard should be had to the existing restrictions on the manufacture and export of machinery and machine tools.

German War Profits.—The latest report of the Bochum Union for Mining and Cast-Steel Manufacture states that the large output of the preceding year had been exceeded by 30,000 tons. A marked increase was also evidenced in the value of the turnover, because during the year no goods such as rails, sleepers, &c., had been manufactured, but almost exclusively products for direct and indirect war purposes. The plant had been heavily taxed, and 2,000,000 marks had been specially reserved on that account and for the transition period. The extension to the steel works and blast-furnaces, and the connection with the Rhine-Herne canal had proceeded during the year, but more urgent work had stood in the way of their completion. They were being proceeded with during the current year. The coal mines had worked most satisfactorily. Thanks to the excellence of the plant, the satisfactory financial position and the efficiency of the staff and men, the prospects were deemed promising. The dividend for last year was fixed at 25 per cent. The Charlotten Hütte, Niederschelden, Siegerland district, paid 16 per cent. for last year, against 8 per cent. for the previous year. The Westphalian Steel Works Company doubled its working profits, as also its production, during last year. The net profits amounted to 1,789,935 marks, liberal war-tax reserve and writings-off having been provided for, of which 20 per cent. arrears on the preference shares were paid, various funds were well financed and 629,935 marks were carried forward.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

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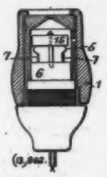
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

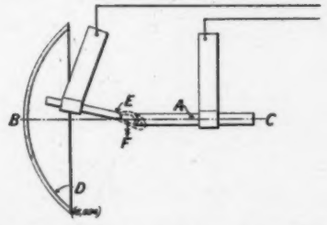
ELECTRICAL APPARATUS.

13,902/15. Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij, Utrecht, Holland. Thermic Telephones. (2 *Figs.*) April 26, 1915. The thermic telephone, which is intended to be introduced directly into the auditory passage of the ear, is enclosed in a tubular casing 1. The heating conductor is constituted by an arch-shaped heating wire, the free portion 5 of which forms the sound producer, whilst



its branches 7, secured in the support 6 of insulating material, are connected to the current conductors leading to the circuit. According to this invention, against the free portion 5 of the heating conductor is placed a heat-absorbing body 15 which, on the one hand, must have sufficient heat capacity to cool strongly the wire 5, 7, which becomes heated during the passage of the current, and, on the other hand, must not cause any short-circuiting. (*Accepted October* 4, 1916.)

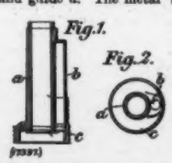
16,694/15. A. H. Railing and A. E. Angold, London. Arc Lamps. (3 *Figs.*) November 26, 1915.—The invention relates more particularly to arc lamps of the kind used for projection purposes. To facilitate focusing, the positive carbon A is placed in the axis of the reflector D in the known manner. But the point E of the negative carbon is slightly above the axis B, C, but lower than the top edge of the positive carbon, so that the arc tends to play on the upper half of the positive carbon because



that is the nearest to the negative carbon. A magnetic influence is provided to counteract this tendency and also to counteract the updraught of the surrounding air until the stream of current conducting vapour strikes the positive centrally and true to its axis. The magnetic field formed by the arc current passing along the carbons and their adjacent electrical connections is as usual, employed for this purpose, but the arrangement is such that the magnetic force tends to blow the arc in the direction F. (*Accepted October* 4, 1916.)

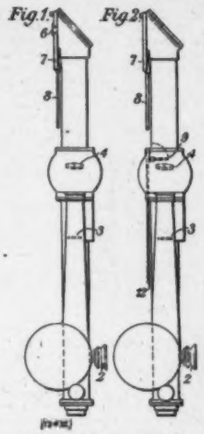
GUNS AND EXPLOSIVES.

17,397/15. C. W. Findlay, London. Grenades. (6 *Figs.*) December 11, 1915.—This invention relates to the manufacture of parts, such as cap chambers, caps or centres, of hand grenades. The cap member *b* is placed on a die or mould suitably shaped to form the base *c* and guide *a*. The metal base portion *c* and



guide *a* are then cast, the base surrounding the adjacent end of the cap and being accurately formed to the required size and shape with threads in one operation, or it may be roughly cast and finished afterwards by machining. (*Accepted September* 27, 1916.)

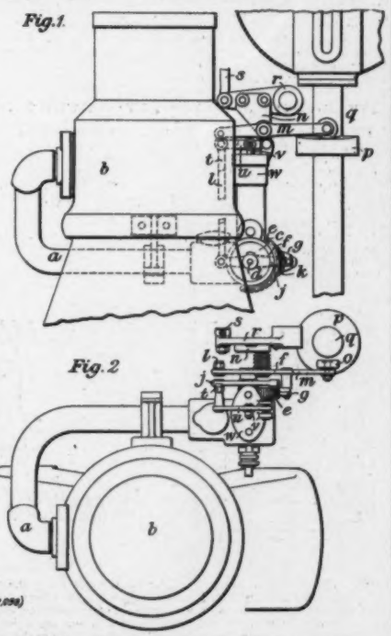
13,476/15. A. Taylor and P. W. Gray, York. Range Finders. (5 *Figs.*) September 22, 1915.—According to the present invention, means are combined with the range finder having periscopic or indirect sighting vision to allow of the testing of the zero point without displacing the range-finding instrument in any way, the latter instrument being combined with the testing apparatus in such a manner that the latter may be moved into or out of the testing position whilst the range finder remains in the normal sighting position. The means consist of a small mirror 6 attached to the wiper pad frame 7 operated, as is known, by a shaft 8 passing down parallel to the tube. In an alternative arrangement, as shown in Fig. 2, a reflecting mirror 9 may be mounted about a pivot carrying a pinion gearing with a rack guided in the periscope tube and provided with an operating handle 12, by which it may be swung into or out of the axis of the periscope tube. Any other form of link operation or gearing may, of course, be adopted. In these constructions it will be necessary to provide means for illuminating the cross wires 3, so that the reflection of the cross wires 3 will pass through the sighting element 4 of the range-finder on to the mirror 6 or 9, as the case may be, thence back through the element 4 and into the eyepiece 2,



whence any lack of coincidence of the image of the cross wires that passes through the fixed half of the object glass with the image passing through the moving half of the object glass can be immediately determined and corrected by adjustment of the optical elements of the range finder, such as 4. (*Accepted October* 4, 1916.)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

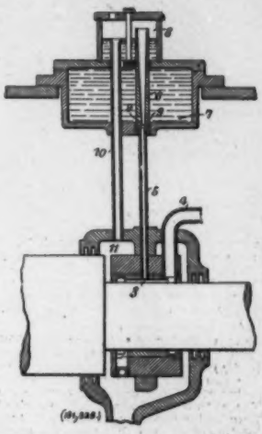
12,098/15. Cole, Marchent and Morley, Limited, R. S. Brailsford and W. W. Spooner, Bradford. Internal Combustion Engines. (2 *Figs.*) August 23, 1915.—The present invention relates to improvements in means for regulating the supply of air to Diesel and similarly actuated internal combustion engines using liquid fuel, according to the load on the engine. In the inlet pipe *a* to the compressor *b* there is arranged a throttle valve *c*. Connected to the spindle *d* of this valve is a semi-circular rack *e*. Loosely mounted on the spindle *d* of the valve is an arm *f* carrying two oppositely directed pawls *g*, which are spring-pressed towards the rack. On a further arm *j*, also loosely mounted on the spindle *d*, is carried a shield *k* which is normally located between the pawls *g* and the rack *e*. The pawl arm *f* is connected by a link *l* to a lever *m*, which is mounted on a movable fulcrum-plate *n*, and at its outer end carries a roller *o* which bears on a cam race *p* on the governor spindle *q*, whereby a continuous oscillation is imparted to the arm *f* and pawls *g*.



The means for forming a movable fulcrum for the lever *m* consist of the plate *n*, which is connected to a lever *r* mounted on a stationary part of the engine, while the outer end of this lever *r* is connected by the rod *s* to the governor mechanism, to rise and fall therewith. From this arrangement it will be seen that, as the speed of the engine tends to vary owing to varying loads, the rod *s* will move and so alter the position of the movable fulcrum *n* of the lever *m* which is operated by the cam race *p*, causing the path through which the pawls *g* are oscillated to be also altered, which will enable the pawls to act on the rack *e* at one or other end of the shield *k*, and so adjust the valve *c*. The shield arm *j* is connected up through the rod *t* and lever *u* to the plunger rod *v* of a pressure plunger in the cylinder *w*, so that the alteration of the pressure in the air bottles, air pipe or like, caused by the adjustment of the valve *c* leading to the compressor, will cause the shield *k* to move in its path between the rack *e* and the pawls *g*. The adjustment of the parts is such that when the pressure has reached the desired point to enable the correct amount of air to be injected into the cylinders of the engine for the then load, the shield will have moved into such a position as to prevent the pawls from acting further on the rack, until such time as the load on the engine is altered. (*Accepted October* 4, 1916.)

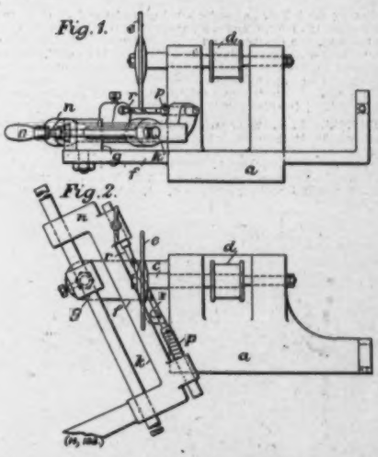
MACHINE AND OTHER TOOLS, SHAFTING, &c.

101,528. Svenska Turbinfabriks Aktiebolaget Ljungstrom, Finspong, Sweden. Forced Feed Lubrication. (1 *Fig.*) July 8, 1916.—According to this invention, a branch pipe 5 of comparatively small diameter is led from the bearing, preferably from the grooves 3, to a nozzle 6, placed in an oil reservoir 7 above the bearing. The nozzle has its outlet into an oil cup 8, above the reservoir 7, so that the volume of oil pouring over the edge of the nozzle can be seen. The nozzle is further provided with one or several openings 9 near the base of the reservoir 7. For leading the surplus oil back to the oil pump there is provided an outlet pipe 10, the upper end of which



is at a suitable height in the cup 8 below the level of the top of the nozzle 6; this pipe, by means of a groove 11 in the bearing casing, communicates with the oil-pump. When the oil pump is started and oil streams in through the pressure pipe 4, it will also be pressed up through the small pipe 5, so that the oil reservoir 7 will be filled with oil, during the oil supply to the bearing the oil reservoir is thus filled to the edge of the outlet pipe 10. It should be observed that the oil during the time it is supplied under pressure to the bearing cannot stream back to same through the openings 9, as the oil, on account of the kinetic energy of the oil jet in the pipe 5, will pass the holes 9 and stream over the edge of the nozzle 6. (*Accepted October* 4, 1916.)

14,198/15. I. Best, Manchester. Grinding Twist Drills. (5 *Figs.*) October 7, 1915.—*a* is the bed of the machine provided with bearings in which is mounted a shaft *c* with a driving pulley *d* and carrying a grinding disc *e* having a semicircular periphery. The bed *a* is also provided with a lug *f* to which a block *g* is clamped by a tail-piece and nut. In the block *g* a rod *k* is mounted and clamped by a set screw. On the rod *k* is mounted a carrier *n* provided with a handle *o* whereby it can be reciprocated and rocked on the bar. The carrier *n* is provided with a self-adjusting or spring-pressed "centre" *p* and a hand-adjustable "centre" *r*. The drill *z* is mounted between the centres *p* and *r*, which are adjusted so that the drill can rotate freely on its own axis, and the rod *k* is adjusted at an angle to the axis of the grinding disc *e* according to the pitch of the grooves



of the drill, so that the disc enters one of the grooves, which is then ground by reciprocating the carrier or holder *n* and at the same time pressing the drill against the grinding disc *e*. The co-operation of the disc *e* with the groove rotates the drill whilst the latter is being reciprocated. When one groove has been ground, the drill is adjusted in the centres *p* and *r* for the grinding of the other groove. An adjustable stop may be provided for limiting the rocking of the carrier or holder towards the disc *e*. For grinding clearance behind the cutting edges of the grooves, a cylindrical grinding disc is employed, the peripheral face of which is of lesser width than the pitch of the grooves. The parts are so adjusted that the drill is rotated so that its axis is parallel to the axis of the clearance grinding disc. (*Accepted October* 4, 1916.)

15,529/15. G. Bilham, London. Facing Tools. (7 *Figs.*) November 4, 1915.—This invention refers to facing, recessing and countersinking tools. The tool holder 1 is made of low-grade tool steel, the upper end being turned to fit a Morse cone and the lower end turned to suit the diameter of the hole to be faced. The central portion of the body is bored to receive the

Fig. 1.

Fig. 2

high-grade steel cutter 2, the remainder of the hole, of which only a portion fits the cutter, is enlarged for clearance, except the top portion, which is drilled and tapped to receive the screw 3. The cutter is secured by the key 4, the space between the screw 3 and the upper end of the cutter being filled and the upward pressure taken by a piece of suitable material. (*Accepted October* 4, 1916.)

100,354. Firm Hasler A.-G., vormals Telegraphen-Werkstatte von G. Hasler, Berne, Switzerland. Shaft Couplings. (1 *Fig.*) April 28, 1915.—1 and 2 are the main shafts. 3 and 4 are the two parts of the spherical coupling member, which has tubular projections 5 and 6 in which the shafts are journalled. The parts 3 and 4 are joined to each other with a lap joint, and are held together by a bolt or rod 8 perpendicular to the plane of this joint. On this bolt is mounted a hollow

connecting shaft 9 formed with bevel gears 10 and 11 at its ends, which mesh with bevel gears 12 and 13 on the main shafts. In the drawing, the shafts 1 and 2 are shown in direct alignment with each other. By rotating either of the parts 3 and 4, the shaft journalled in that part can be placed at any angle between 180 deg. and 90 deg. to the other main shaft, and the uniformity of the speed of the driven shaft is in no way affected by the adjustment. (*Accepted October* 4, 1916.)

17,327/15. L. A. Wharrad, Redditch, and H. H. Knowles, Studley. Milling Rods and Wires. (7 *Figs.*) December 10, 1915.—The spindles *b*, *b*1, of the milling cutters *a*, *a*1, respectively are mounted eccentrically in bushes in the standards *d* of the machine. The bushes are capable of a partial rotation so as to adjust the spiral milling cutters *a*, *a*1, towards or away from

Fig. 1.

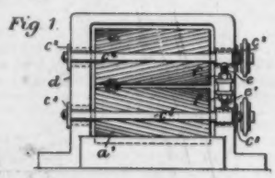
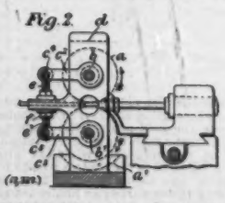


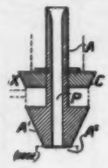
Fig. 2.



each other, and thereby the space between the cutters is also adjusted to suit the work to be done. The bushes are turned or adjusted through the arms e^3, e^3, in one with the bushes respectively, the said arms e^3, e^3 at one end being connected to the arms e^2, e^2, at the other end by rods e^4, e^4. On the rods e^4, e^4, are collars e^5, e^5, in one with the right and left-handed screw pins e, e1, respectively, which screw pins are drawn together or are moved apart by the turning of nut *f*, with which the screw pins e, e1, engage. The nut *f* is supported in a fork-like bracket on the standard *d*. (*Accepted* October 4, 1916.)

PUMPS.

9,202/15. W. Matthewman, Ingleton. Pump Valves. (7 *Figs.*) June 22, 1915.—This invention relates to pump valves having a passage or passages through the valve member, and having in conjunction with the valve member a number of seats capable of covering side and end ports, adapted to isolate side ports when acted on by inlet pressure, and allow incoming air to pass through a passage in the interior of the member. The valve barrel A has a passage P formed therethrough, and at one end a valve member A^1. The lower A^2 of the valve is greater in area than the hole in the collar C which the valve barrel passes



through. When inlet pressure is admitted to the device, the valve will be moved on to its lower seat so that a port X between the collar C and end A^1 of the valve is isolated. A rubber ring C^1 may be provided to prevent the passage of air between the barrel and the seating collar C. Owing to the end A^2 being greater in area than the area of the hole in the collar C, immediately the inlet pressure is reduced the valve will lift from its lower seating and allow air to pass to the port at X, which is uncovered by such lift. When the valve is used with a pump it will open after every stroke of the pump, or when the action ceases if a continuous current pump is used. (*Accepted October* 4, 1916.)

RAILWAYS AND TRAMWAYS.

15,588/15. Weldless Couplings, Limited, London, and I. H. Pilot, Brighton. Railway Wagon Couplings. (19 *Figs.*) November 4, 1915.—This invention relates to the manufacture of couplings of the kind described in Specification No. 27,683 of 1912. The billet of square cross section from which the coupling is formed is submitted to stamping operations in

Fig. 1. *Fig. 2.*

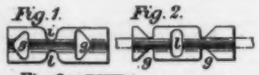
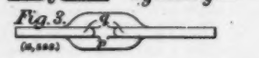


Fig. 3.



compound dies which successively form two sets of grooves *g*, *g*, and *l*, *l*, in planes at right angles to one another, whereby the blank is divided into three sections, viz., a central portion containing the metal for the centre link and the portions of the end links engaging therewith, and two end portions for the other parts of the end links. The centre and end portions are then flattened in planes at right angles to one another, as shown in Fig. 3. (*Accepted October* 4, 1916.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

101,454. A. W. Bennis, Bolton. Furnace Fire Bars. (3 *Figs.*) September 22, 1915.—According to the present invention, a plurality of transverse bars are carried side by side on moving longitudinal elements to present hollow troughs over the bases of which are arranged stationary cleaning slides, the relative motion thereby keeping the air passage through the troughs clear of accumulating ash and the like. A plurality of detachable bars 1 (Fig. 1) are supported within a frame formed by the parts 41, 42 and 43, and, as shown, may be in the form of plates having a rectangular opening 2 serving as an air passage which leads to passages 3 communicating with the fire bed. The inner sides of the bar bounding the air passage 2 may be ribbed to

Fig. 1.

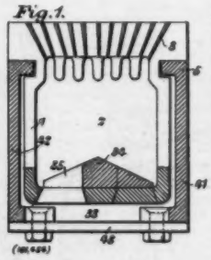
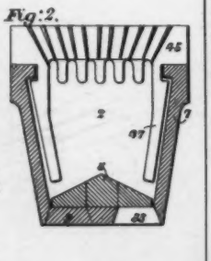
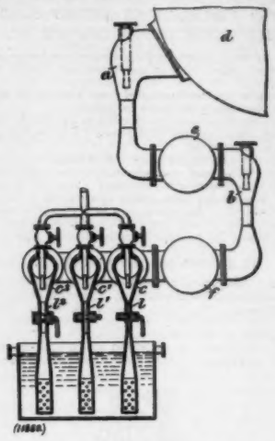


Fig. 2.



provide a large cooling area. This also has the effect of preheating the air. In the form illustrated, a cleaning slide 34, having holes 35, is adapted to slide over the lower surfaces of the bottom of the bars 1 to allow ash or the like to fall out through the holes 33. The bars 1 are prevented from becoming detached from the parts supporting them by keyed portions or flanges 5 in the parts 41, 42 engaging in recesses in the bars. In the modified construction shown in Fig. 2, the bars 45 are open on the under side and have sides 47 extending down within the walls 7 of the trough. The cleaning slide 8 in this instance is arranged working actually on the base of the trough 9 and holes in it adapted to cover or uncover holes 33 in the base of the trough according as the trough is reciprocated. (*Accepted September* 27, 1916.)

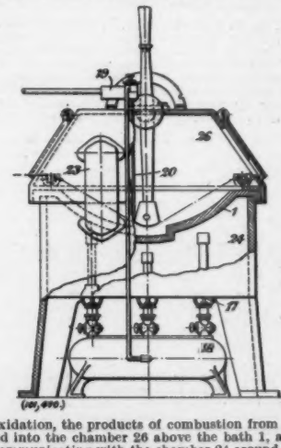
11,860/15. D. B. Morison, Hartlepool. Steam Condensers. (3 *Figs.*) August 17, 1915.—This invention relates to the discharge of aerated vapour from a steam condenser under vacuum by means of steam-operated ejectors. The invention consists in arranging multiple final ejectors *c*, *c*1, *c*2, in parallel with each other and in series with the ejectors *a* and *b*, *e* and *f* being intermediate condensing receivers. The combining tubes *b*, *b*1, *b*2, are provided with cocks and the steam supply to the ejectors is provided with valves, so that one or more of the ejectors may be brought into use when desired. The ejectors *c*, *c*1, *c*2, may each have any suitable air capacity, and in the arrangement illustrated they are designed for capacities for



discharging respectively 1, 2 and 4 lb. of air, contained in the aerated vapour withdrawn from the condenser *d*, per unit of time. (*Accepted September* 27, 1916).

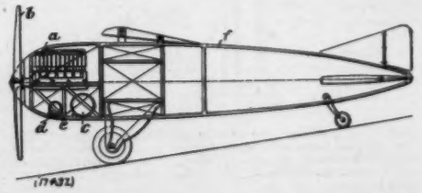
MISCELLANEOUS.

101,470. I. Hall, Birmingham. Coating Wire. (2 *Figs.*) September 16, 1915.—The firing of the bath 1 is effected through a series of Bunsen burners 17, fed from a common equalising chamber 18 of comparatively large volume, the gas supply to which is under control of a thermostatic regulator 19 comprising thermostatic elements 20 which depend into the bath, a valve controlling the supply of fuel and levers transmitting and magnifying the movement of the thermostat to the controlling valve. The fuel inlet from the thermostat appliance 19 to the gas-equalising chamber 18 is indicated at 22. To minimise



surface oxidation, the products of combustion from the fuel are introduced into the chamber 26 above the bath 1, and external flues 23 communicating with the chamber 24 around the burner 17 are arranged to discharge the products of combustion into the upper or melting and coating chamber, the gases finally making their escape through an outlet on the top of the enclosing cover. By passing the products of combustion to the upper surface of the metal in the bath 1, the waste heat is utilised in preheating the metal and surface oxidation is also considerably minimised. (*Accepted September* 27, 1916.)

17,437/15. A. A. Holle and A. W. Judge, Thames Ditton, and The Varioplane Company, Ltd., London. Aeroplanes. (4 *Figs.*) December 13, 1915.—The invention relates to aeroplanes of the single fuselage type. The engine *a*, the propeller *b*, and the intermediate gearing, when such is used, either with or



without the tanks *c* and *d* for the fuel and lubricating oils, and the silencer, are mounted in a detachable frame *e* adapted to form an extension of the fuselage *f*, the power unit being capable of being readily mounted on or dismounted from the fuselage. (*Accepted September* 27, 1916.)

JAPANESE STEEL.—The promoters of the Oriental Iron Smelting Company, of Japan, propose to work the Taochun iron mine at Anhui, China, by taking over a concession obtained by the Chino-Japanese Industrial Development Company from the Pekin Government. The company proposes to start with a capital of 12,462,500 dols.